AIC 2015 TOKYO

Color and Image

Midterm Meeting of the International Colour Association (AIC)

19-22 May 2015 Tokyo, Japan

Book of Abstracts

日本色彩学会
THE COLOR SCIENCE ASSOCIATION OF JAPAN

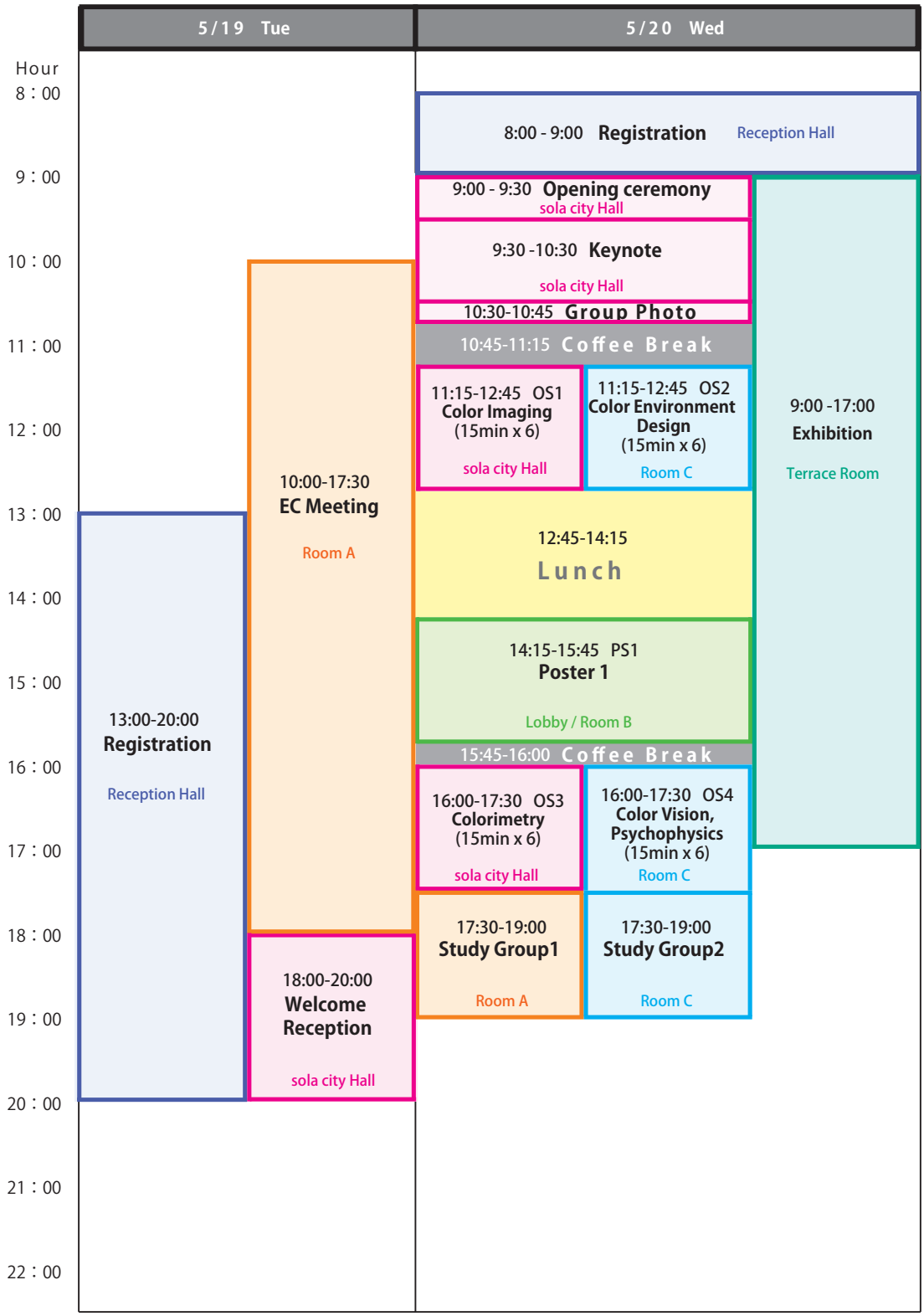
AIC

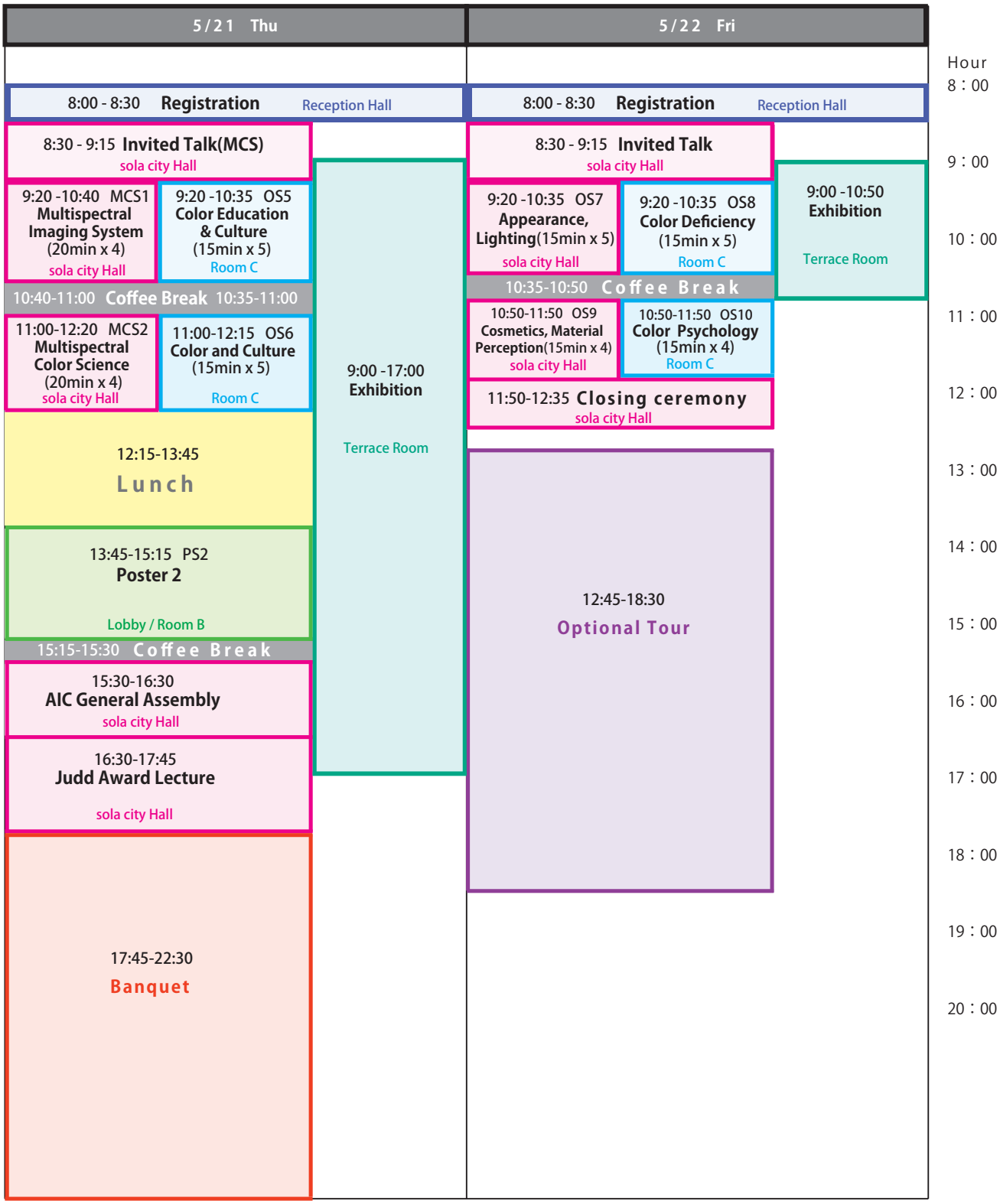
mcs
MCS 2015

BYK
Additives & Instruments

KONICA MINOLTA

Time Table


5/19 Tue
5/20 Wed
Hour
8 : 00
9 : 00
10 : 00
11 : 00
12 : 00
13 : 00
14 : 00
15 : 00
16 : 00
17 : 00
18 : 00
19 : 00
20 : 00
21 : 00
22 : 00
8:00 - 9:00 Registration Reception Hall
9:00 - 9:30 Opening ceremony sola city Hall
9:30 -10:30 Keynote sola city Hall
10:30-10:45 Group Photo
10:45-11:15 Coffee Break
11:15-12:45 OS1 Color Imaging (15min x 6) sola city Hall
11:15-12:45 OS2 Color Environment Design (15min x 6) Room C
9:00 -17:00 Exhibition Terrace Room
12:45-14:15 Lunch
14:15-15:45 PS1 Poster 1 Lobby / Room B
15:45-16:00 Coffee Break
16:00-17:30 OS3 Colorimetry (15min x 6) sola city Hall
16:00-17:30 OS4 Color Vision, Psychophysics (15min x 6) Room C
17:30-19:00 Study Group1 Room A
17:30-19:00 Study Group2 Room C
10:00-17:30 EC Meeting Room A
13:00-20:00 Registration Reception Hall
18:00-20:00 Welcome Reception sola city Hall


5/21 Thu
5/22 Fri
Hour
8:00 - 8:30 Registration Reception Hall
8:00 - 8:30 Registration Reception Hall
8:30 - 9:15 Invited Talk(MCS)
sola city Hall
9:20 -10:40 MCS1
Multispectral Imaging System
(20min x 4)
sola city Hall
9:20 -10:35 OS5
Color Education & Culture
(15min x 5)
Room C
10:40-11:00 Coffee Break 10:35-11:00
11:00-12:20 MCS2
Multispectral Color Science
(20min x 4)
sola city Hall
11:00-12:15 OS6
Color and Culture
(15min x 5)
Room C
12:15-13:45
Lunch
13:45-15:15 PS2
Poster 2
Lobby / Room B
15:15-15:30 Coffee Break
15:30-16:30
AIC General Assembly
sola city Hall
16:30-17:45
Judd Award Lecture
sola city Hall
17:45-22:30
Banquet
9:00 -17:00
Exhibition
Terrace Room
8:30 - 9:15 Invited Talk
sola city Hall
9:20 -10:35 OS7
Appearance, Lighting(15min x 5)
sola city Hall
9:20 -10:35 OS8
Color Deficiency
(15min x 5)
Room C
10:35-10:50 Coffee Break
10:50-11:50 OS9
Cosmetics, Material Perception(15min x 4)
sola city Hall
10:50-11:50 OS10
Color Psychology
(15min x 4)
Room C
11:50-12:35 Closing ceremony
sola city Hall
12:45-18:30
Optional Tour
9:00 -10:50
Exhibition
Terrace Room
8 : 00
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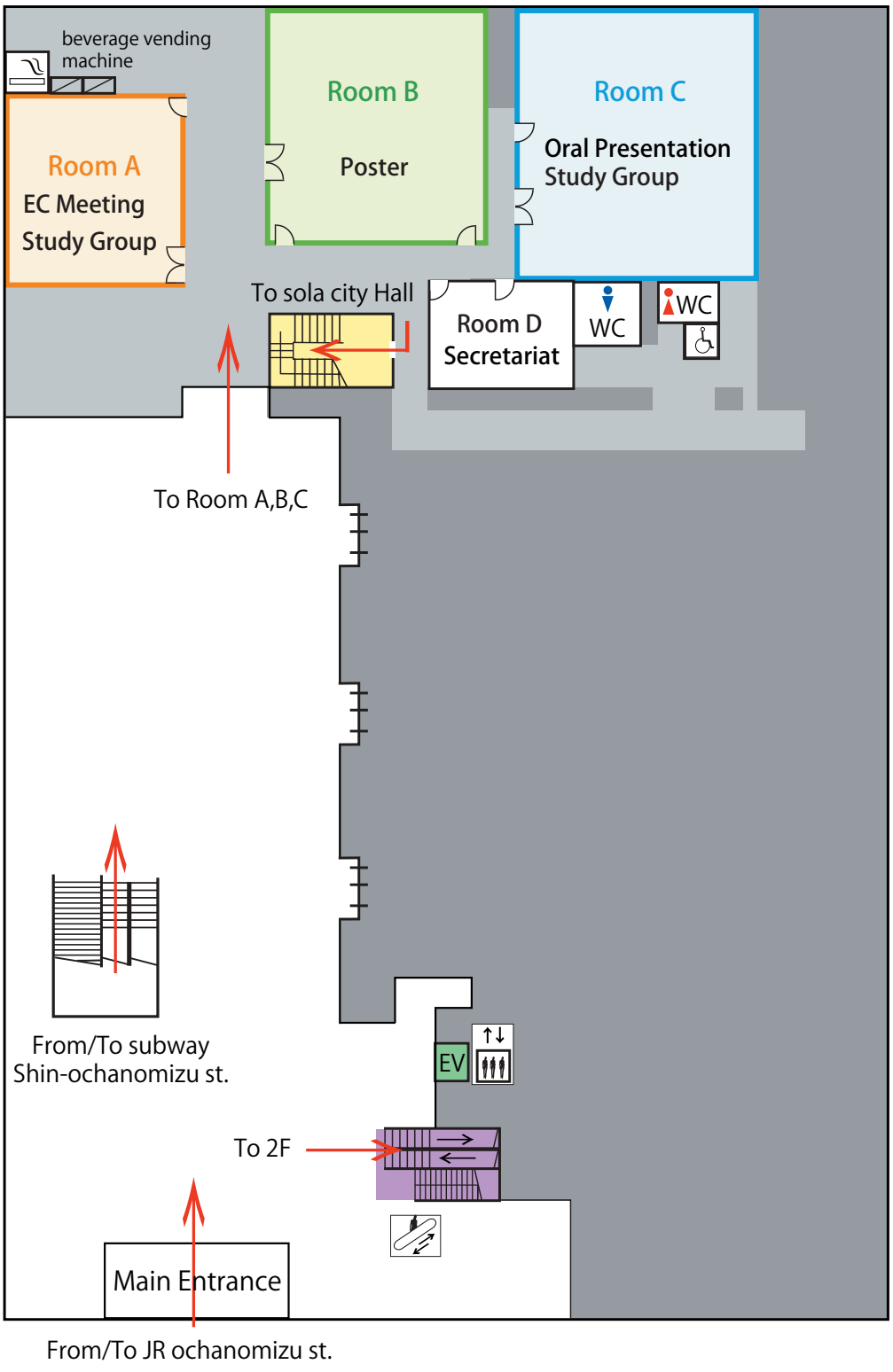
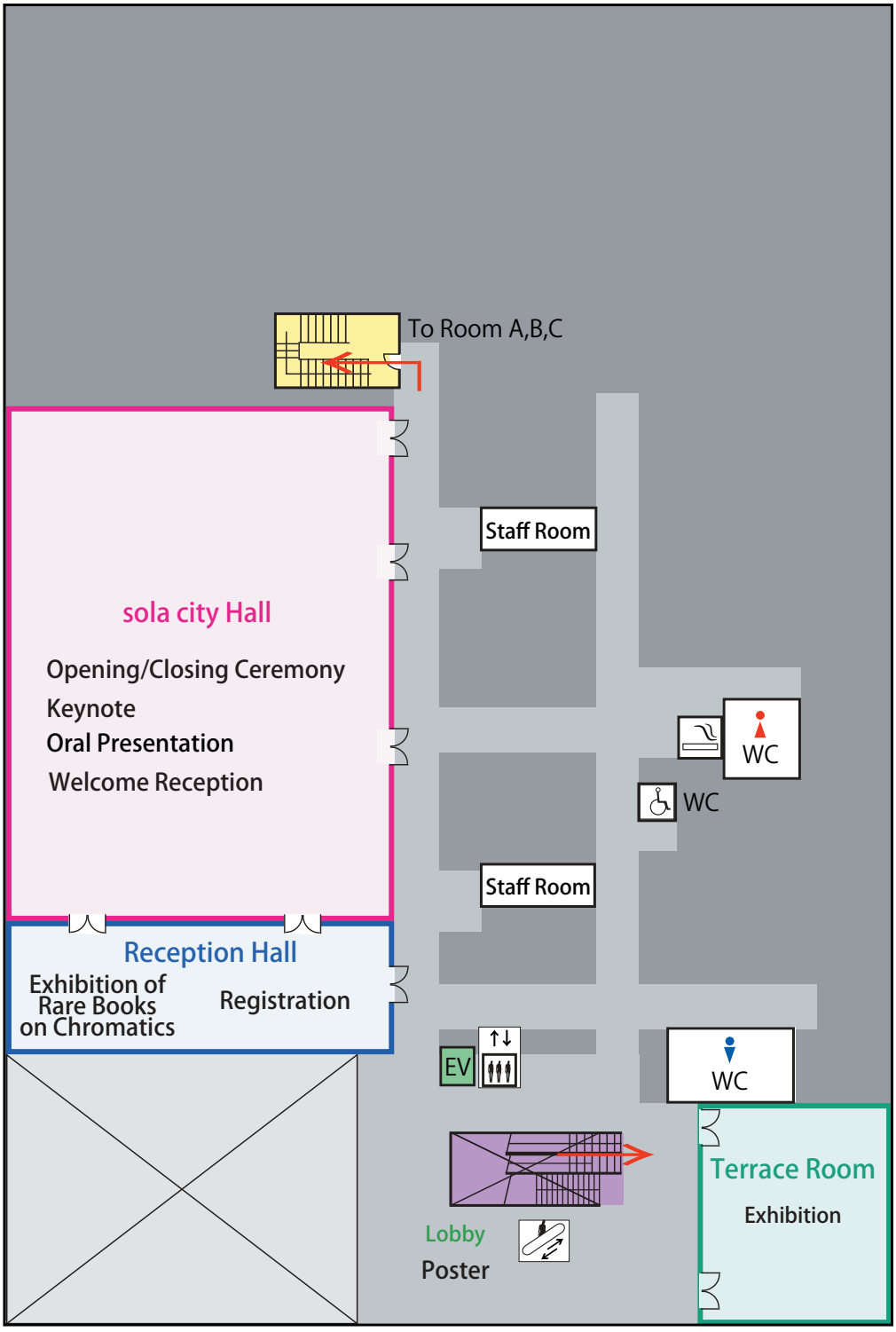
17 : 00
18 : 00
19 : 00
20 : 00

Floor map (sola city Conference Center)

1F



2F


To Room A,B,C
Staff Room
sola city Hall
Opening/Closing Ceremony
Keynote
Oral Presentation
Welcome Reception
WC
WC
Staff Room
Reception Hall
Exhibition of Rare Books on Chromatics
Registration
EV
WC
Terrace Room
Exhibition
Lobby
Poster

AIC2015 TOKYO Color and Image

Midterm Meeting of the International Colour Association (AIC)

19-22 May 2015, Ochanomizu sola city Conference Center, Tokyo, Japan

Book of Abstracts

Editors: Hirohisa Yaguchi
Katsunori Okajima
Taiichiro Ishida
Kikuko Araki
Motonori Doi
Yoshitsugu Manabe

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Book of abstracts

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AIC President's Message

For a second time the AIC is to hold a conference in Japan, in Tokyo this time, thanks to the initiative of the Color Science Association of Japan. On the first occasion, the 8th AIC Congress was held in Kyoto, and everyone remembers it as a great event. This year it is to be mid-term meeting dedicated to "Image and Color". This is a very modern issue that encompasses many fields: from acquisition and reproduction of color images to processing the images and their use in computer vision. Many other interesting topics are also included, such as color in computer graphics, colorimetry, digital archiving of art, color vision, color psychology and emotion, environmental color, design, color culture and color education. All of them in their relationship to color images. The conference will also include the16th International Symposium on Multispectral Color Science, opening the science of color to the world of spectral imaging of large projections today.

We live in a world full of images. Communication between humans relies increasingly on the acquisition and use of images in any method of exchanging information. Optoelectronic audiovisual media of acquisition and reproduction of images and the internet have revolutionized the way we communicate and images are continuously used in color. As a result, new challenges arise: the reliability and quality of images, the development of new algorithms of image processing in order to find new applications, for example in computer vision or in medicine, etc.

Color is an added and differential value in images. We can say that it brings a great deal of transcendental information to those images that are part of our daily life. The visual images that form our eyes together with the retina and the brain processes involved, acquire a higher dimension when they are in color. We can say the same for the images obtained with a camera. I think the opportunity to discuss and exchange ideas in the field of color images at this conference will be extraordinary.

The Color Science Association of Japan is one of the most active regular members of the AIC. Proof of this is the high participation of Japanese scientists in all the AIC congresses and the participation of its members in the management of the AIC as members of the Executive Committee and as Chairs of Study Groups. From these lines I want to publicly thank these efforts that have supported the AIC since its founding and recognize the prestige of so many Japanese scientists in the field of color. I would also like to thank the great effort and work done by the organizing committee of AIC 2015 to enable this conference to be the success which I am sure it will be. The quality of the communications which are collected together in this book is sufficient proof of the magnificent meeting we are going enjoy together.

I wish all attendees a fruitful and enjoyable AIC 2015!

Javier Romero

President, International Colour Association

AIC - International Colour Association

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Chair: Verena M. Schindler (Switzerland)
Study Group on Color Vision and Psychophysics (CVP)
Chair: Katsunori Okajima (Japan)
Study Group on The Language of Color (LC)
Chair: Dimitris Mylonas (United Kingdom)

Color Science Association of Japan President's Preface

As the President of the Color Science Association of Japan I would like to welcome all of our participants to AIC2015, being held from May 19th to the 22nd in Tokyo.

Eighteen years ago in 1997 the Color Science Association of Japan held Asia's first international Congress in Japan's old capital of Kyoto, where participants from various countries had the chance to deepen friendships through lively discussions on their research, while simultaneously learning about Japan's traditions and colors. We are very happy that once again, eighteen years since then, the AIC's Midterm Meeting will once again be held in Japan.

The AIC is composed of members from more than 30 countries, and many people from various nations are gathering in Tokyo for AIC2015. We would like for this not only to be a place for research reports and scientific and technical discussions, but hope from the bottom of our hearts that it will be a chance for developing friendships which go beyond the boundaries of location or age. We, the members of the Color Science Association of Japan, have planned the program of AIC2015 Tokyo to be one that participants can enjoy. We hope you will feel happy that you participated in AIC2015 Tokyo. Additionally, to commemorate AIC2015 Tokyo, at the conference site on May 19th we will hold a symposium entitled "Considering Color and Japanese Culture from the Perspective of Food, Clothing, and Shelter" and, on the 20th, an exhibition of rare books by well-known authors such as Michel-Eugène Chevreul.

Now Tokyo is bustling with energy in preparation for the 2020 Olympic Games. We hope AIC2015 participants can observe Tokyo as it grows even more dynamically, and further develops the infrastructure to handle this major international event smoothly.

We, the members of the Color Science Association of Japan, are looking forward to meeting you in Tokyo.

Takayoshi Fuchida
President, The Color Science Association of Japan

Welcome to AIC2015 TOKYO

On behalf of the Steering Committee of AIC2015 TOKYO, I would like to welcome you all to the Midterm Meeting of the International Colour Association in the exciting and traditional city of Tokyo, from May 19-22, 2015.

The meeting is organized by the International Colour Association and the Color Science Association of Japan in cooperation with Ministry of Education, Culture, Sports, Science and Technology (MEXT), Ministry of Economy, Trade and Industry, National Institute of Advanced Industrial Science and Technology, Science Council of Japan, The Tokyo Chamber of Commerce and Industry.

This meeting will provide a unique forum, bringing together researchers, academics, students, artists, architects, industrialists, engineers, designers, computer scientists, lighting experts, media types, exhibitors and business leaders. This year the 16th International Symposium on Multispectral Color Science (MCS 2015) is organized as part of AIC2015. We have chosen “Color and Image” as a theme of AIC2015. The word “image” has a very wide meaning; not only visible presentation, such as imaging devices, displays, pictures, etc., but also a presentation of anything from people’s minds. So, we have called for papers from a variety of fields as follows:

Color Imaging
Color Image Processing
Computational Color Image
Color in Computer Graphics
Color Reproduction
Color Image Quality
Multispectral Color Science
Multispectral Imaging
Multispectral Image Acquisition / Display
Spectral Image Applications
Colorimetry / Colorimetric Imaging / Lighting
Digital Archiving of Art
Color Vision / Psychophysics / Physiology
Color Psychology / Emotion
Perception of Material / Surface Quality
Color Image Design
Color Environmental Design
Cosmetics
Personal Color
Color Culture
Color Education

Although as many as 324 papers have been submitted from more than 20 countries, we have to accept a limited number of papers because of limitation of time and space. Finally, we selected 60 oral and 172 papers presentations covering a diverse range of color research and applications based on peer reviews by the International Program Committee.

We have invited three speakers who all are admirable leaders in their fields. Following the opening ceremony on Wednesday, May 20, Ms. Kazuyo Sejima, the recipient of the prestigious Prizker Architecture Prize with Ryue Mishizawa of SANNA, will deliver the Keynote Lecture on the title "The Gathering Space" focusing on her recent works. She will introduce the environment and architecture enhanced by color. During the morning session, invited papers are presented. On Thursday, May 21, Professor Jon Y. Hardeberg of the Gjøvik University College, Norway will give an invited lecture, "Multispectral colour imaging: time to move out of the lab?" He has beeen recommended by MCS and will talk about his main research interests which includes multispectral color imaging, print and image quality, colorimetric device characterization, color management, and cultural heritage imaging. On Friday, May 22, the final day, Professor Hidehiko Komatsu of National Institute for Physiological Sciences talks on "Neural representation of color in visual cortex." He is currently project leader for a large research project "Brain and Information Science on shitsukan (material perception)" funded by MEXT and will talk on neural representation of color in higher visual cortex, neural mechanisms of gloss perception, texture processing, and multimodal integration in material recognition.

Following the General Assembly on Thursday, May 21, the AIC Judd Awards ceremony will be held. The 2015 Judd Award is to be received by Professor Françoise Viénot, Muséum National d'Histoire Naturelle, France. She will deliver the Judd Award Lecture on "On the dimensionality of the colour world."

Finally, I would like to note acknowledgements as the Chair of the Steering Committee. The journey today would not have been possible without a dedicated and hard working Steering Committee all of whom have devoted a considerable amount of time to ensuring that AIC2015 TOKYO will be a great success. I would like to offer my personal and sincere thanks to all of you.

I would also like to thank our sponsors whose generosity and support is greatly appreciated. I would like to ask that you all reciprocate their support when you are seeking products or services offered by our sponsors.

I hope that you all leave the AIC2015 with warm feelings for the exciting city of Tokyo, will have renewed friendships and made new friends in the global color community, and, importantly, be refreshed and stimulated with new ideas to further develop your research in the world of color.

Hirohisa Yaguchi
Chair, Steering Committee of AIC2015 TOKYO

Welcome to MCS2015 TOKYO

As a MCS general chair, I would like to welcome all of you to AIC/MCS2014 TOKYO, which is held in Tokyo, Japan, during May 19–22, 2015. This year, the 16th International Symposium on Multispectral Color Science (MCS 2015) is organized as part of AIC2015 TOKYO.

Many aspects of the multi- and hyper- spectral image acquisition, analysis, and rendering have been extensively researched and studied along with the technological advances in hardware devices, software systems, and signal processing algorithms. Also, spectral imaging science and technology is more and more exploited in numerous applied technologies such as computer vision, computer graphics, biology, medicine, cosmetics, digital archiving, printing, display, and remote sensing. As a consequence, a variety of problems generally encountered have been reformulated, successfully solved, and sometimes cast into their new contexts rising new scientific challenges.

The first MCS symposium was launched at Chiba University, Japan in 1999. Since 2001 the multispectral symposium has been organized by a consortium of international researchers, mostly incorporated into larger international conferences and continues to grow. The 16th International Symposium (MCS2015 TOKYO) builds on the tradition to bring together researchers in the field of spectral color science and imaging.

We received about 40 paper submissions to the MCS group. The AIC/MCS Program Committee finally decided to accept 8 papers for MCS oral, about 20 papers for MCS poster, and some papers for AIC poster from the contributed papers, based on peer reviews by the International Program Committee. Paper presentations related on MCS are scheduled mostly on Thursday, May 21. The morning session starts with an invited lecture by Professor Jon Y. Hardeberg (Gjøvik University College, Norway), entitled "Multispectral colour imaging: time to move out of the lab," which is then followed by the Oral session. The poster presentations are in the afternoon.

I wish that all participants will successfully exchange their knowledge, technologies, and ideas with old and new friends, and enjoy the conference and the most beautiful season in Japan.

Shoji Tominaga
General Chair of MCS2015 Tokyo

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Ministry of Education, Culture, Sports, Science and Technology
National Institute of Advanced Industrial Science and Technology
Science Council of Japan
The Tokyo Chamber of Commerce and Industry

With the Support of:

Architectural Institute of Japan
Color Universal Design Organization
Coating Equipment Manufacturers Association of Japan
The Illuminating Engineering Institute of Japan
The Imaging Society of Japan
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The Institute of Electrical Engineers of Japan
The Institute of Electronics, Information and Communication Engineers
The Institute of Image Information and Television Engineers
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Japanese Cosmetic Science Society
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Japanese Society for the Science of Design
The Japanese Psychological Association
The Japanese Psychonomic Society
The Japanese Society of Ophthaimological Optics
The Japanese Society of Printing Science and Technology
The Japan Paint Manufacturers Association
Japan Society of Colour Material
The Japan Society of Home Economics
Japan Society of Kansei Engineering
The Japan Society of Mechanical Engineers
The Optical Society of Japan
The Society of Cosmetic Chemists of Japan
The Society of Photography and Imaging of Japan
Vision Society of Japan

Suga Weathering Technology Foundation

Keynote Lecture

9:30 - 10:30 sola city Hall

Chair: Hirohisa Yaguchi

The Gathering Space

Kazuyo SEJIMA

Oral Papers

11:15-12:45 (sola city Hall)
OS1: Color Imaging

Chairs: Alessandro Rizzi & Takahiko Horiuchi

OS1-1 How Multi-Illuminant Scenes Affect Automatic Colour Balancing
Liwen Xu and Brian Funt

OS1-2 The Generalised Reproduction Error for Illuminant Estimation
Graham Finlayson and Roshanak Zakizadeh

OS1-3 Rank-Based Camera Spectral Sensitivity Estimation
Graham Finlayson and Maryam Mohammadzadeh Darrodi

OS1-4 Comparing Colour Camera Sensors Using Metamer Mismatch Indices
Ben Hull and Brian Funt

OS1-5 Advanced Measurement Technology for Image Clarity
Hideo Kita and Shigeo Suga

OS1-6 Painting by Numbers: Transforming Fields and Edges to Vectors
Carinna Parraman, Paul O'Dowd and Mikaela Harding

11:15-12:45 (Room C)
OS2: Color Environment Design

Chairs: Taiichiro Ishida & Jin-Sook Lee

OS2-1 Perception of Colours Illuminated by Coloured Light
Shabnam Arbab and Barbara Szybinska Matusiak

OS2-2 Effects of Furniture Colour on Apparent Volume of Interior Space
Keishi Yoshida and Masato Sato

OS2-3 Ideal GRID Model for Color Planning of Living Space
Tien-Rein Lee

OS2-4 Case Studies of Color Planning for Urban Renewal
Sari Yamamoto

OS2-5 Building Colours in Taipei – Taking Wanhua District as an Example
Chia-Chi Chang, Ting-Tsung Ho and Li-Chen Ou

OS2-6 Pritzker Prize Laureates' Colour Preferences
Malvina Arrarte-Grau

16:00-17:30 (sola city Hall)
OS3: Colorimetry

Chairs: Haisong Xu & Yoshitsugu Manabe

OS3-1 Computing Tristimulus Values: An Old Problem for a New Generation
Zhifeng Wang, Tianyi Li, M. Ronnier Luo, Manuel Melgosa, Michael Pointer and Changjun Li

OS3-2 Variability in Colour Matches between Displays
Phil Green, Srikrishna Nuduramati and Ivar Farup

OS3-3 A Comparison Study of Camera Colorimetric Characterization Models Considering Capture Settings Adjustment
Jingyu Fang, Haisong Xu and Wei Ye

OS3-4 Evaluation and Analysis of *YUTEKI-TENMOKU* Visual Effect on Traditional Ceramic Applied Gonio- Photometric Spectral Imaging and Confocal Type Laser Scanning Microscopy
Masayuki Osumi

OS3-5 Measuring Skin Colours Using Different Spectrophotometric Methods
YuZhao Wang, Ming Ronnier Luo, Xiao Yu Liu, Haiyan Liu and BinYu Wang

OS3-6 Assessing Light Appearance in Shopping Mall
Yuteng Zhu, Ming Ye, Wenjie Huang, Muhammad Farhan Mughal, Muhammad Safdar and Ming Ronnier Luo

16:00-17:30 (Room C)
OS4: Color Vision, Psychophysics

Chairs: Yoko Mizokami & Li-Chen Ou

OS4-1 Pupillary Light Reflex Associated with Melanopsin and Cone Photorecetors
Seiichi Tsujimura and Katsunori Okajima

OS4-2 Experimental Research on EEG Characteristics in Red, Green, Blue, and White Color Space Consequent on the Degree of Depression
Heewon Lee, Hanna Kim, Jiseon Ryu and Jinsook Lee

OS4-3 Hue-Tone Representation of the Nayatani-Theoretical Color Order System
Hideki Sakai

OS4-4 Colour Appearance in the Outdoor Environment
Ya-Chen Liang, Li-Chen Ou and Pei-Li Sun

OS4-5 Color Play: Gamification for Color Vision Study
Shida Beigpour and Marius Pedersen

OS4-6 Using Visual Illusions to Expand the Available Colors for Making Mosaics
I-Ping Chen and Wei-Jie Chiou

Study Group Meetings

17:30-19:00 (Room A)

Study Group on Environmental Color Design

Chair: Verena M. Schindler

17:30-19:00 (Room C)

Study Group on The Language of Color

Chair: Dimitris Mylonas

Poster Papers

14:15-15:45 Poster 1 (Room B/Lobby)

Chairs: Shoji Sunaga & Norihiro Tanaka

Room B : PS1-1~64
Lobby : PS1-65~87

PS1-1 Colour Image, Fashion Design and Identity
Larissa Noury

PS1-2 Contemporary Art and the Unfoldings of Colour
Laura Carvalho

PS1-3 Comparison of Slovene Colour Identities by Researchers A. Trstenjak and M. Tusak with Colors on Slovenian Municipality Flags
Vojko Pogacar

PS1-4 A Comparison of Color Schemes and Images in the Package Design of Sweets in the US and Japan
Kyoko Hidaka

PS1-5 Human Monochromatic Impressions on Multichromatic/Colorless Phenomena and Concepts
Ayana Deguchi, Akira Asano, Chie Muraki Asano and Katsunori Okajima

PS1-6 How to Create a Colour Education that Fosters Price-winning Design Students
Ivar Jung

PS1-7 Influence of Odors Function and Colors Symbolism in Odor-Color Associations: Comparative Study between Rural and Urban Regions in Lebanon
Léa Nehmé, Reine Barbar, Yelena Maric and Muriel Jacquot

PS1-8 Differences of Generation Dependences of Preferences between Colors and Styles in Women's Fashion
Chie Muraki Asano, Kanae Tsujimoto, Akira Asano and Katsunori Okajima

PS1-9 Effect of Color Appeared in Signage to Identify Gender of Thai
Chanida Saksirikosil, Kitirochna Rattanakasamsuk and Ploy Srisuro

PS1-10 Development of Three Primary-color Transparent Cubes for Learning Subtractive Color Mixing Visually
Keiichi Miyazaki

PS1-11 Multicolor LED Lighting Device with a Microprocessor for Demonstrating Effects of Lighting on Color Appearance
Takashi Nakagawa

PS1-12 The Effect of Environment Colour on Behavioural Inhibition
Nicholas Ciccone and Stephen Westland

PS1-13 Influence of Light Incident Angle and Illuminance Intensity on Visual Comfort and Clarity
Yinqiu Yuan, Li-Ching Chuo, Hsin-Pou Huang and Ming-Shan Jeng

PS1-14 Colour Terms in the Interior Design Process
Douha Y Attiah, Vien Cheung, Stephen Westland and David Bromilow

PS1-15 Effects of Classroom Wall Color on Students
Fazila Duyan and Rengin Ünver

PS1-16 A Study on the Evaluation Process of Facade Colour Parameters
Esra Küçükkılıç Özcan and Rengin Ünver

PS1-17 Correlation between Personal and Classroom color Preferences of Children
Rengin Ünver and Fazila Duyan

PS1-18 Research on the Coexistence of Color between Buildings and Exterior Advertising that Create a Cityscape ~ focusing on the Okamoto district of Kobe ~
Yoshifumi Takahashi and Ikuko Narita

PS1-19 Colour Management in the Colour Design Process
Per Jutterstrom

PS1-20 Exploring Combinations of Color Patterns in Nature
Akemi Yamashita and Naoko Takeda

PS1-21 Visual Impressions Induced by Colours of Facial Skin and Lips
Mei-Ting Liu, Hsing-Ju Hung, Wen-Ling Deng and Li-Chen Ou

PS1-22 International Comparison of Uses of Color for Pictograms
Yuki Akizuki, Michico Iwata and Hirotaka Suzuki

PS1-23 The Influence of Color on the Perception of Cartographic Visualisations
Zbyněk Štěrba and Jan D. Bláha

PS1-24 Evaluation of Colour Appearances Displaying on Smartphones
X. Gao, E. Khodamoradi, L. Guo, X. Yang, S. Tang, W. Guo, Y. Wang

PS1-25 Colour Management for High Dynamic Range Imaging
Keith D. M. Findlater

PS1-26 Development of a Wide-Gamut Digital Image Set
Stephen Westland, Qianqian Pan, Yuan Li and Soojin Lee

PS1-27 Construction of Display Profiles Using Simplicial Maps and Application to Color Reproduction of Displays
Masashi Yamamoto and Jinhui Chao

PS1-28 "Psycolorsynthesis": An Introduction of 10-Color Communication Method
Chiori Ohnaka

PS1-29 Perceptually Inspired Gamut Mapping between Any Gamuts with Any Intersection
Javier Vazquez-Corral and Marcelo Bertalmío

PS1-30 Color Correction Operation for 3D Scanning Models
Kai-Lin Chan, Lin Lu, Tzung-Han Lin, Hung-Shing Chen, Chia-Pin Cueh and Kang-Yu Liu

PS1-31 Correcting for Induction Phenomena on Displays of Different Size
Marcelo Bertalmío

PS1-32 KANSEI Evaluation of Color Images Presented in Different Blue Primary Displays
Toshiya Hamano, Takashi Fuseda, Tomonori Tashiro, Tomoharu Ishikawa, Hiroyuki Shinoda, Kazuhiko Ohnuma, Keisuke Araki and Miyoshi Ayama

PS1-33 New Proposal for Advanced Measurement Technology for Image Clarity
Hideo Kita, Shigeo Suga and Jack A. Ladson

PS1-34 Analysis of Color Appearance of Metallic Colors and Pearlescent Colors Using Multi-angle Spectrophotometer
Yu-Wen Chiu, Hung-Shing Chen, Chia-Pin Cueh and Kang-Yu Liu

PS1-35 HDR imaging - Automatic Exposure Time Estimation - A novel approach
Miguel Angel Martinez-Domingo, Eva M. Valero, Javier Hernández-Andrés and Javier Romero

PS1-36 Real-time Green Visibility Ratio Measurement
Motonori Doi, Akira Kimachi and Shogo Nishi

PS1-37 Evaluation of 20 p/d-safe Colors Used in Image Color Reduction Method for Color Deficient Observers
Takashi Sakamoto

PS1-38 Silkscreen Printing on Cotton Fabrics with Soil Colorant
Somporn Jenkunawat, Pratoomthong Trirat and Kulthanee Siriruk

PS1-39 Estimation of the Environment Illumination Color Using Distribution of Pixels
Noriko Yata, Yuki Arai and Yoshitsugu Manabe

PS1-40 A Spectral Reflectance Measurement System for Human Skin by Using Smartphone
Seungwan Hong, Norihiro Tanaka and Kosuke Mochizuki

PS1-41 Colour Management for High Quality Reproduction on Uncoated Papers
Maja Strgar Kurecic, Lidija Mandic, Ante Poljicak and Diana Milcic

PS1-42 A Real-Time Multi-spectral CG Rendering Method for Building with Scene Illumination
Chihiro Sakurai, Norihiro Tanaka and Kosuke Mochizuki

PS1-43 Color Mapping between a Pair of Similar Facial Images with and without Applying Cosmetics
Lin Lu, Hung-Shing Chen and Neng-Chung Hu

PS1-44 The Consistent Color Appearance Based on the Display-referred
Yasunari Kishimoto, Hitoshi Ogatsu and Hirokazu Kondo

PS1-45 The Study of Museum Lighting: The Optimum Lighting and Colour Environment - the Proposal for the Colour Quality Index -
Yuki Nakajima and Takayoshi Fuchida

PS1-46 Developing Test Targets for Color Management of Full Color Three-dimensional Printing
Yu-Ping Sie, Pei-Li Sun, Yun-Chien Su, Chia-Pin Cueh and Kang-Yu Liu

PS1-47 The Effect of Training Set on Camera Characterization
Semin Oh, Youngshin Kwak and Heebaek Oh

PS1-48 Reproducing the Old Masters: A Study in Replicating Dark Colours with Inkjet Printing
Melissa Olen and Joseph Padfield

PS1-49 A New Metric for Evaluating the Closeness of Two Colors
Yasuki Yamauchi, Yusuke Iida, Yuki Kawashima and Takehiro Nagai

PS1-50 Image and Color Space Clustering for Image Search
Akinobu Hatada

PS1-51 Restoration of Color Appearance by Combining Local Adaptations for HDR Images
Yuto Kubo, Takao Jinno and Shigeru Kuriyama

PS1-52 Image Quality Index for Perceiving Three-dimensional Effect in Mobile Displays
Chun-Kai Chang, Hirohisa Yaguchi and Yoko Mizokami

PS1-53 Imageries of Edible Souvenirs Evoked by Colours and Visual Textures of Packages
Shuo-Ting Wei

PS1-54 A Study of the Preference and Orientation of "The Sense-oriented"
Takashi Inaba

PS1-55 Color Peference Measured by Paper-Format Implicit Association Test
Shinji Nakamura and Aya Nodera

PS1-56 SSVEP Response Study for Low Semantic Images
Syntyche Gbèhounou, Enrico Calore, Francois Lecellier, Alessandro Rizzi and Christine Fernandez-Maloigne

PS1-57 My Own Colours
Kristiina Nyrhinen

PS1-58 Hue and Tone Effects on Color Attractiveness in Mono-Color Design
Uravis Tangkijviwat and Warawan Meksuwan

PS1-59 A Study on Silver Metallic Color Preference - A Comparison of Responses between Japanese and Thai People -
Mikiko Kawasumi, Kamron Yougsue, Chanprapha Phuangsuwan, Kanrawee Tawonpan and Ken Nishina

PS1-60 Colors' Relations to Other Things in My Works
Helena Lupari

PS1-61 Color Preference of Preschoolers : Compared to Adults' Surmise
Wei-Chun Hung, Pei-Li Sun and Li-Chen Ou

PS1-62 Influence of the Typical Color in Object Memory Task
Mikuko Sasaki and Yasuhiro Kawabata

PS1-63 Neural Basis of Color Harmony and Disharmony Based on Two-color combination
Takashi Ikeda and Naoyuki Osaka

PS1-64 Psychological Hue Circle of Blind People and Development of a Tactile Color Tag for Clothes
Saori Okudera, Ken Sagawa, Yuko Nakajima, Natsumi Ohba and Shoko Ashizawa

PS1-65 Examination of Method for Decreasing Unpleasantness Caused by Strong Brightness of Smart-phone Displays in Dark Adaptation
Itsuki Miyamae, Hyojin Jung, Saori Kitaguchi and Tetsuya Sato

PS1-66 A Spectral-based Color Vision Deficiency Model Compatible with Dichromat and Anomalous Trichromat
Hiroaki Kotera

PS1-67 Colour Information in Design
Seahwa Won, Stephen Westland, Kishore Budha and Bruce Carnie

PS1-68 Relationship between Perceived Whiteness and Color Vision Characteristics
Ichiro Katayama, Koichi Iga, Shoko Isawa and Tsuneo Suzuki

PS1-69 An Experiment of Color Rendering with 3D Objects
Laura Blaso, Cristian Bonanomi, Simonetta Fumagalli, Ornella Li Rosi and Alessandro Rizzi

PS1-70 Adapting and Adapted Colors under Colored Illumination
Mitsuo Ikeda, Chanprapha Phuangsuwan and Kanwara Chunvijitra

PS1-71 Color Constancy Depends on Initial Visual Information
Chanprapha Phuangsuwan, Mitsuo Ikeda and Kanwara Chunvijitra

PS1-72 Neighboring Color Effect on the Perception of Textile Colors
Youngjoo Chae, John H. Xin and Tao Hua

PS1-73 The Impact of Light at the Perception of Colours in Architecture, State of the Art Study and Suggestions for Further Research
Shabnam Arbab and Barbara Szybinska Matusiak

PS1-74 Evaluation of Cloth Roughness and Smoothness by Visual and Tactile Perceptions: Investigation of Cloth Photography Method for Online Shopping
Tomoharu Ishikawa, Yuya Akagawa, Kazuma Shinoda, Shigeru Inui, Kazuya Sasaki, Keiko Miyatake and Miyoshi Ayama

PS1-75 Study of Color Preferences of Gac Fruit Blended with Mixed Mushroom Juice
Wattana Wirivutthikorn and Somporn Jenkunawat

PS1-76 Luminance Contrast of Thai Letters Influencing Elderly Vision
Kitirochna Rattanakasamsuk

PS1-77 Color Rendering Analysis Based on Color Pair Evaluation under Different LED Lighting Conditions
Qing Wang, Haisong Xu, Jianqi Cai and Wei Ye

PS1-78 The Relationship between Whiteness Perception of Watercolor Illusions and Color Vision Characteristics
Shoko Isawa, Koichi Iga, Ichiro Katayama and Tsuneo Suzuki

PS1-79 Influence of Daylight Illumination in the Visual Saliency Map of Color Scenes
Juan Ojeda, Juan Luis Nieves and Javier Romero

PS1-80 Comparison between Multispectral Imaging Colors of Single Yarns and Spectrophotometric Colors of Corresponding Yarn Swatches
Lin Luo, Hui-Liang Shen, Si-Jie Shao and John H. Xin

PS1-81 New Color Rendering Index Based on Color Discriminability and Its Application to Evaluate Comfortability of Illuminants
Yasuhisa Nakano, Toshiki Nagasaki, Ryu Toyota, Jiro Kohda and Takuo Yano

PS1-82 Color Monitoring Method under High Temperature during Oven Cooking
Yuji Nakamori, Hiroyuki Iyota, Hideki Sakai, Taiki Matsumoto and Shuhei Nomura

PS1-83 Woodblock Printing as a Means for 2.5D and 3D Surface Evaluation
Teun Baar, Melissa Olen, Carinna Parraman and Maria Ortiz Segovia

PS1-84 The Relationships between Colors of Neck, Cheek, and Shaded Face Line Affects Beauty of Made-up Face
Youhei Ishiguro, Mamiko Nakato, Erika Tokuyama, Nao Matsushita and Minori Yamahara

PS1-85 Experimantal Method Suggested for Optical Observation of Anisotropic Scattering
Akio Kawaguchi and Hirofumi Ninomiya

PS1-86 Color Measurement of Meat in Cooking under LED Lightings with Different Spectral Distributions
Akari Kagimoto, Risa Shiomi, Shino Okuda, Mami Masuda, Katsunori Okajima, Hideki Sakai and Hiroyuki Iyota

PS1-87 Color Temperature and Illuminance of Main Streets with Day and Night Illumination in the Center of Osaka, Japan
Haruyo Ohnoh

Invited Talk (MCS)

8:30 - 9:15 sola city Hall

Chair: Shoji Tominaga

Multispectral colour imaging: Time to move out of the lab?
Jon Yngve HARDEBERG

Oral Papers

9:20-10:40 (sola city Hall)
MCS1: Multispectral Imaging System

Chairs: Lindsay MacDonald & Masaru Tsuchida

MCS1-1 Surface Spectral Reflectance Estimation with Structured Light Projection
Grzegorz Mączkowski, Krzysztof Lech and Robert Sitnik

MCS1-2 Multispectral Imaging System Based On Tuneable LEDs
Muhammad Safdar, Ming Ronnier Luo, Yuzhao Wang and Xiaoyu Liu

MCS1-3 Evaluation of Hyperspectral Imaging Systems for Cultural Heritage Applications Based on a Round Robin Test
Sony George, Irina Mihaela Ciortan and Jon Yngve Hardeberg

MCS1-4 Spectral Gigapixel Imaging System for Omnidirectional Outdoor Scene Measurement
Motoki Hori, Naoto Osawa, Keita Hirai, Takahiko Horiuchi and Shoji Tominaga

11:00-12:20 (sola city Hall)
MCS2: Multispectral Color Science

Chairs: Jon Yngve Hardeberg & Keita Hirai

MCS2-1 Handheld Hyperspectral Imaging System for the Detection of Skin Cancer
Xana Delpueyo, Meritxell Vilaseca, Santiago Royo, Miguel Ares, Ferran Sanabria, Jorge Herrera, Francisco J. Burgos, Jaume Pujol, Susana Puig, Giovanni Pellacani, Jorge Vázquez, Giuseppe Solomita and Thierry Bosch

MCS2-2 Empirical Disadvantages for Color-Deficient People
Joschua Simon-Liedtke and Ivar Farup

MCS2-3 Spectral Reflectance Recovery Using Natural Neighbor Interpolation with Band-Divided Linear Correction
Tzren-Ru Chou and Tsung-Chieh Sun

MCS2-4 Evaluation of Gastrointestinal Tissue Oxygen Saturation Using LEDs and a Photo Detector
Yoshitaka Minami, Takashi Ohnishi, Koki Kato, Hiroyuki Wasaki, Hiroshi Kawahira and Hideaki Haneishi

9:20-10:35 (Room C)
OS5: Color Education & Culture

Chairs: Verena M. Schindler & Kohji Yoshimura

OS5-1 Are There Ugly Colours?
Ilona Huolman

OS5-2 A Novel Experience in Color Teaching: Master in Color Design & Technology
Alessandro Rizzi, Maurizio Rossi, Cristian Bonanomi and Andrea Siniscalco

OS5-3 The Ambiguous Term of "Saturation"
Karin Fridell Anter, Harald Arnkil and Ulf Klarén

OS5-4 Colour Education and Real Life Colour
Ulf Klarén and Karin Fridell Anter

OS5-5 Color Universes for the Chilean Heritage
Elisa Cordero and Eréndira Martínez

11:00-12:15 (Room C)
OS6: Color and Culture

Chairs: Tien-Rein Lee & Shin'ya Takahashi

OS6-1 Forsius' Second Colour Order Diagram of 1611 from the Iconic Point of View
Verena M. Schindler

OS6-2 Five Colours - A Study of Chinese Traditional Colour
Jie Xu

OS6-3 Meeting New Challenges in Colour Tendencies in Norway
Kine Angelo and Alex Booker

OS6-4 The Image of the Color Red in Letters: A Study Based on the Historical Backgrounds of Russia and Japan
Sasha Krysanova

OS6-5 Japanese Color Names Reflecting Dyeing: With a Focus on Their Color Terms in Brown Regions Including More than 100 Browns
Kohji Yoshimura, Yuko Yamada and Stephen Shrader

Poster Papers

13:45-15:15 Poster 2 (Room B/Lobby)

Chairs: Yasuki Yamauchi & Takuzi Suzuki

Room B : PS2-1~64
Lobby : PS2-65~85

PS2-1 Changes of Color Names and Coloring Materials in Japan
Norifumi Kunimoto

PS2-2 Differences in the Drawings and the Color of the Violence in Children from Three Different Cultures
Georgina Ortiz Hernandez and Mabel López

PS2-3 Color and Image of the City in Environmental Design of Kazimir Malevich
Yulia Griber

PS2-4 Comparative Study about Preference Tendency to Spatial Color Based on Color Recognitions and Emotions among Nations : Focused on Korea and Malaysia
Ji-Young Oh, Heykyung Park, Mai Neo, Jian-Yuan Soh and Min Jae Lee

PS2-5 The Analysis of Door Color on the Traditional Palace of the Kingdom of Joseon
Lu Chen and Jin Sook Lee

PS2-6 Comparison among Three Methods for Thai Colour Naming
Pichayada Katemake, Dimitris Mylonas, Lindsay MacDonald and Amara Prasithrathsint

PS2-7 A Study on Elements Perceived as Traditional among Fabrics and Colors for Hanbok
Ji Hyun Sung and Yung Kyung Park

PS2-8 The Positive Impact of Image by Colour for Vulnerable People
Maria Elena Chagoya

PS2-9 Faith in the Power of Color : Spiritual Revival from the East Japan Earthquake Disaster
Yumi Awano

PS2-10 Types of Smart Cities | Cities Built from the Scratch and Old Cities Transformed into Smart Cities: What Kind of Colours can We Use?
Ana C. Oliveira

PS2-11 The Use of English Colour Terms in Big Data
Dimitris Mylonas, Matthew Purver, Mehrnoosh Sadrzadeh, Lindsay MacDonald and Lewis Griffin

PS2-12 A Proposal of Colour Universal Design Game for Learning Dichromats' Confusion Colours
Shigehito Katsura and Shoji Sunaga

PS2-13 Colour Management: Managing the Intuitive Issue, the Gamut Issue and the Engagement Issue
Philip Henry and Stephen Westland

PS2-14 Suggestion for Teaching Natural Colors through Investigation and Analysis of Current Color Education for Children in Korea
Shin Sangeun, Choi Sueran, Kim Saetbyul and Kim Yoosun

PS2-15 Color Mixture Learning using Personal Computer for Basic Design
Tomoko Mitsutake, Katsuyuki Aihara and Yosuke Yoshizawa

PS2-16 The Art of Colour Harmony: The Enigmatic Concept of Complementary Colours
Harald Arnkil

PS2-17 A Study on Influence of the Culture and Art Experience of Senior Citizens from Relationships between Culture and Art Education Space and Color Emotion Assessment
Hyeyun Son, Yunsun Park and Jinsook Lee

PS2-18 Impressions of Buildings Derived from the Combined Effects of Exterior Colour, Material, and Window Shape
Kazumi Nakayama and Masato Sato

PS2-19 Analysis of Current Colors of Native Plants Growing Naturally in Korea
Yoosun Kim, Sueran Choi, Saetbyul Kim and Sangeun Shin

PS2-20 Effects of Accent Colour on the Apparent Distance to a Wall and the Apparent Volume of an Interior Space: The Validation Experiment in an Actual Space
Wataru Kamijo, Keishi Yoshida and Masato Sato

PS2-21 Metamer Mismatching as a Measure of the Color Rendering of Lights
Hamidreza Mirzaei and Brian Funt

PS2-22 Visual Impression of a Real Room Affected by Lighting Conditions and by Colour and Texture of the Walls
Jau-Yi Wu, Henry Pan and Li-Chen Ou

PS2-23 Suggesting Appropriate Color Range for Indoor Space Based on EEG Measurement
Hanna Kim, Heewon Lee, Mijin Lee and Jinsook Lee

PS2-24 Development of the Interior Color Coordination Recommendation System of Living Space for University Student Living Alone Using Genetic Algorithm
Tatsunori Matsui, Keiichi Muramatsu, Kazuaki Kojima, Mai Kawashima and Miho Saito

PS2-25 Chromatic Integration of the Architectural Surfaces with the Environment: Analysis and Classification of Case Studies
Alessandro Premier and Katia Gasparini

PS2-26 Color Appearance of Red Printing Ink for Color Vision Deficiency
Terumi Kato, Yoko Mizokami, Masami Shishikura, Shinichiro Taniguchi, Tomomi Takeshita, Fumiko Goto and Hirohisa Yaguchi

PS2-27 A Study on the Utilization of Korean Saekdong Color in the Textile Arts
Kum-Hee Ryu

PS2-28 Color Adjustment for an Appealing Facial Photography
Kyeongah Jeong and Hyeon-Jeong Suk

PS2-29 Understanding Popular Relationships among Colors through the Network Analysis for Crowd Sourced Color Data
EunJin Kim and Hyeon-Jeong Suk

PS2-30 Eliciting the Color Bizarreness Effect Using Photographs
Aiko Morita and Saki Funakoshi

PS2-31 Texture in Color Emotions
Ivana Tomic, M Mar Lazaro, Ana Carrasco-Sanz, Ana Benjumea, Li-Chen Ou, Jose Antonio Garcia, Igor Karlovic and Rafael Huertas

PS2-32 Individual's Color Preference and Personality of Feeling Active and Passive Good Emotion, Pleasantness and Comfortableness
Shin'ya Takahashi and Takashi Hanari

PS2-33 Colour Emotions for Antioxidant-Enriched Virgin Olive Oils
Luis Gómez-Robledo, Piedad Limon, Ruperto Bermejo and Manuel Melgosa

PS2-34 A Study on Difference in Color Sensibility Judgment between Professionals & Non-professionals
Younjin Lee

PS2-35 Age Effects on Garments Color Harmony
Min Huang, Zeyang Li, Guihua Cui, Haoxue Liu and M. Ronnier Luo

PS2-36 Effects of Color and Aroma of Roasted Tea on the Predicted Taste and Palatability
Atsushi Haruta, Kosuke Asano, Akihisa Takemura, Shino Okuda and Katsunori Okajima

PS2-37 A Study of Relationship between Physical Value and Psychological Value in PCCS
Tadayuki Wakata and Miho Saito

PS2-38 Psychological Effects of Meal Tray Color on the Visual Palatability of Meals among Individuals with Low Vision - The Effects of Brightly Toned Colors
Keiko Tomita, Maya Inamura and Kimiko Ohtani

PS2-39 A Comparison between the Impact of Short and Long Wavelengths of Light on Sleepiness and Mood
Mengxi Yun, Sayaka Aritake, Sunao Uchida and Miho Saito

PS2-40 Experimental Study of Common Factors between Impressions of Wall-Paper Colors and Sounds in Living Environments
Miho Saito, Yuriko Oishi and Taiichiro Ishida

PS2-41 The Investigation of Factors Influencing the Impression of Color Harmony
Yuh-Chang Wei and Wen-Guey Kuo

PS2-42 The Hidden Image – A Strategy to Put an Unwanted Phenomenon in Its True Light
Salome Egger

PS2-43 Does Colour Really Affect Pulse Rate and Blood Pressure ?
Soojin Lee and Stephen Westland

PS2-44 Effects of Font Size on Visual Comfort for Reading on a Tablet Computer
Hsin-Pou Huang, Yi-Ho Bai and Li-Chen Ou

PS2-45 Influence of Spectral Component of White Light on the Discomfort Glare - Contribution of Image and Non-image Forming Pathways -
Toshihiro Toyota and Taka-Aki Suzuki

PS2-46 Low-chroma Colors Suppress Luminance-driven Brain Activation Measured by fMRI
Ippei Negishi and Keizo Shinomori

PS2-47 A New Evaluation Method Using the 100-hue Test and Age Trends in Color Distinction Ability
Masayuki Harada

PS2-48 Study on Image Statistics When Color Attracts Human Attention
Yasuhiro Hatori, Ichiro Kuriki, Kazumichi Matsumiya and Satoshi Shioiri

PS2-49 Prior Knowledge Modulates Peripheral Color Appearance
Bilge Sayim, Erik Myin and Tilde Van Uytven

PS2-50 Decision of Validness in Custom Color Name of JIS Z 8102
Yosuke Yoshizawa

PS2-51 Evaluation of Color Appearance under LED and OLED Lighting Based on the Data Obtained by a New Color Category Rating Method
Taiichiro Ishida, Yasuki Yamauchi, Takehiro Nagai, Hiroyuki Kurimoto, Yuhei Shoji and Tatsuya Tajima

PS2-52 Influence of Position of Colored Panels to Entire Pattern's Visibility
Ryouta Nakaya, Ippei Negishi and Keizo Shinomori

PS2-53 A Color Coordination Support System Based on Impression from Color and Readability of Text
Yoshihiko Azuma, Kazuhiro Yamamoto, Miyuki Kobayashi and Eri Komiyama

PS2-54 Study on Visual Recognition of Specula Reflection about Silk and Cotton Textile
Eun Jung Lee and Masayuki Osumi

PS2-55 An Experiment on Color Differences Using Automotive Gonioapparent Samples
Manuel Melgosa, Luis Gómez-Robledo, Esther Perales, Elisabet Chorro, Francisco Miguel Martínez-Verdú and Thomas Dauser

PS2-56 Legibility of Printed Thai Letters Comparison on Young and Elderly
Boonchai Waleetorncheepsawat

PS2-57 On the Perceived Brightness of Whites
Dragan Sekulovski, Kees Teunissen, Mart Peeters, Yue-Jun Sun and Remy Broersma

PS2-58 Smart Lighting Providing Different Optimal Visiual Illumination for Different Objects
Neng-Chung Hu, Horng-Ching Hsiao and Li-Chi Su

PS2-59 Prediction of Acceptable Lightness Difference in Painting on Automobile Surface with Different Materials Based on Multi-angle Measurement
Kohei Wakai

PS2-60 Visual Perception and Criteria for Good Lighting
Johanna Enger and Anahita Davoodi

PS2-61 Space Brightness Affected by a Scenic View through a Window
Shogo Yamada, Ryousuke Tanaka, Hiroyuki Shinoda and Yasuhiro Seya

PS2-62 Influence of Surface Properties on Material Appearance
Ming-Kang Lan, Tien-Rein Lee and Vincent C. Sun

PS2-63 Visual Evaluation of a Wooden-finish Room and the Colorimetry of Wood
Shigeko Kitamura, Jun Tsuchiya and Shoji Sunaga

PS2-64 Total Appearance of Metallic Coatings using a Stereo Capture System
Min-Ho Jung, Vien Cheung and Peter A. Rhodes

PS2-65 Statistical Image Analysis for Evaluating Face Shine: Cosmetic Research
Takanori Igarashi, Takahiro Naoki, Masataka Seo and Yen-Wei Chen

PS2-66 High Dynamic, Spectral and Polarized Natural Light Environment Acquisition
Philippe Porral, Patrick Callet and Philippe Fuchs

PS2-67 Development of Skin Reflectance Prediction Model Using a Skin Data
Kaida Xiao, Mengmeng Wang, Tushar Chauhan, Jingjing Yin, Changjun Li, Ronnier Luo and Sophie Wuerger

PS2-68 Comparing CSI and PCA in Amalgamation with JPEG for Spectral Image Compression
Muhammad Safdar, Ming Ronnier Luo and Xiaoyu Liu

PS2-69 A System for Analyzing Color Information with the Multi-spectral Image and Its Application
Junyan Luo, Yoko Mizokami, Hirohisa Yaguchi, Yohei Takara, Fuminori Ando, Takahiro Fujimori and Naoki Noro

MCS Poster Papers

PS2-70 Quality Comparison of Multispectral Imaging Systems Based on Real Experimental Data
Raju Shrestha and Jon Y. Hardeberg

PS2-71 LED-based Gonio-hyperspectral System for the Analysis of Automotive Paintings
Francisco J. Burgos, Meritxell Vilaseca, Esther Perales, Elísabet Chorro, Francisco M. Martínez-Verdú, José Fernández-Dorado, José L. Alvarez-Muñoz and Jaume Pujol

PS2-72 Multispectral Image Estimation from RGB Image Based on Digital Watermarking
Kazuma Shinoda, Aya Watanabe, Madoka Hasegawa and Shigeo Kato

PS2-73 Image Correction for a Multispectral Imaging System Using Interference Filters and Its Application
Shogo Nishi and Shoji Tominaga

PS2-74 Development of Multi-bands 3D Projector
Ryotaro Miwa, Yoshitsugu Manabe and Noriko Yata

PS2-75 Perceived Quality of Printed Images on Fluorescing Substrates under Various Illuminations
Steven Le Moan and Ludovic Gustafsson Coppel

PS2-76 To Predict Reality in Virtual Environments : Exploring the reliability of colour and light appearance in 3D-models
Beata Stahre Wästberg, Jacqueline Forzelius and Monica Billger

PS2-77 Altering Perceived Depth of Objects with Colored Lighting
Ruth Genevieve Ong and Nan-Ching Tai

PS2-78 A Model for Estimation of Overprinted Colors on *Nishiki-e* Printings
Sayoko Taya, Takuzi Suzuki, Noriko Yata and Yoshitsugu Manabe

PS2-79 Ethical Considerations on Gene Therapy for Color-Deficient People
Joschua Simon-Liedtke

PS2-80 Robust Cross-Domain Reflectance Estimation
Christoph Godau

PS2-81 Colorama: Extra Color Sensation for the Color-Deficient with Gene Therapy and Modal Augmentation
Joschua Simon-Liedtke

PS2-82 Benchmarking a Grating-based Spectral Imaging System
M. James Shyu and Ting-Yun Lin

PS2-83 Experimental Evaluation of Chromostereopsis with Varying Spectral Power Distribution of Same Color
Masaru Tsuchida, Minoru Mori, Kunio Kashino and Junji Yamato

PS2-84 Haze and Convergence Models: Experimental Comparison
Jessica El Khoury, Jean-Baptiste Thomas and Alamin Mansouri

PS2-85 Hyperspectral Reflectance Reconstruction Using a Filter-based Multispectral Camera
Wei-Chun Hung, Pei-Li Sun and Raymond Jiang

Judd Award Lecture

16:30 - 17:45 sola city Hall

Chair: Nick Harkness

On the dimensionality of the colour world
Françoise VIÉNOT

Invited Talk

8:30 - 9:15 sola city Hall

Chair: Katsunori Okajima

Neural Representation of Color in Visual Cortex

Hidehiko KOMATSU

Oral Presentation

9:20-10:35 (sola city Hall)
OS7: Appearance, Lighting

Chairs: Ronnier Luo & Hiroyuki Shinoda

OS7-1 Assessing Glare Using LED Sources Having Different Uniformity Patterns
ShiNing Ma, Yang Yang, Ming Ronnier Luo, XiaoYu Liu and BinYu Wang

OS7-2 Evaluation of the Performance of Different Colour Rendering Indices Employed in LEDs
Haiting Gu, Xiaoyu Liu, Ming Ronnier Luo, Binyu Wang and Haiyan Liu

OS7-3 A Study on the Lighting of Bathroom for the Elderly
Jiyoung Park, Chanung Jeong, Eunji Seo and Jinsook Lee

OS7-4 Sitting Posture Based Lighting System to Enhance the Desired Mood
Hyunjoo Bae, Haechan Kim and Hyeon-Jeong Suk

OS7-5 Colour Lighting Based on Chromatic Strength
Toru Kitano, Tetsuji Yamada and Kosuke Oshima

9:20-10:35 (Room C)
OS8: Color Deficiency

Chairs: Youngshin Kwak & Takashi Sakamoto

OS8-1 Influences to Color Constancy by Wearing the Optical Dichromatic Filter or the Aged Lens Filter under Static and Rapidly-Changed Colored Illuminations
Mio Hashida, Ippei Negishi and Keizo Shinomori

OS8-2 Spectral Functional Filters for Optical Simulation of Dichromats in Color Discrimination
Keizo Shinomori, Kanae Miyazawa and Shigeki Nakauchi

OS8-3 What Are Memory Colors for Color Deficient Persons?
Jia-Wun Jian, Hung-Shing Chen and Ronnier Luo

OS8-4 Establishment of a Model Colour Palette for Colour Universal Design
Kei Ito, Tomomi Takeshita, Fumiko Goto, Masafumi Nishigaki, Teruo Kobayashi, Mitsumasa Hashimoto, Yosuke Tanaka, Koichi Iga, Shunsuke Watanabe, Koki Okagawa and Mitsuyoshi Maekawa

OS8-5 Color Universal Design
Yasuyo G. Ichihara

10:50-11:50 (sola city Hall)
OS9: Cosmetics, Material Perception

Chairs: Takanori Igarashi & Motonori Doi

OS9-1 An Investigation of the Appearance Harmony Using Real Materials and Displayed Images
Midori Tanaka and Takahiko Horiuchi

OS9-2 The Colour of Gold
Lindsay MacDonald

OS9-3 Preferred LED Lighting for Wood Surfaces and Colored Surfaces
Markus Reisinger

OS9-4 Development of a Facial Imaging System and New Quantitative Evaluation Method for Pigmented Spots
Kumiko Kikuchi, Yuji Masuda, Tetsuji Hirao, Kiyoshi Sato, Yoko Mizokami and Hirohisa Yaguchi

10:50-11:50 (Room C)
OS10: Color Psychology

Chairs:Osvaldo Da Pos & Shinji Nakamura

OS10-1 Colour Preference and Harmony for Athletic Shoe Designs
Wei-Hsuan Chao, Ji-Yuan Huang, Chung-Chien Lan and Li-Chen Ou

OS10-2 A Study on Silver Metallic Color Preference - A Comparison of Responses by Age and Gender in Thailand -
Kamron Yongsue, Mikiko Kawasumi, Chanprapha Phuangsuwan and Kanrawee Tawonpan

OS10-3 Effects on Impression of Taste in Color Stimuli
Masato Sakurai, Yusuke Michinaka and Takahiro Yoshikawa

OS10-4 The Color Image of Dichromats and Anomalous Trichromats
Yuria Noguchi and Muneo Mitsuboshi

Keynote Lecture, Invited Talks, Judd Award Lecture

Keynote Lecture

Wednesday, May 20, 9:30-10:30 (sola city Hall)

The Gathering Space

Kazuyo SEJIMA
SANAA, Japan

Focusing on her recent works, Kazuyo Sejima will introduce the environment and architecture enhanced by color.
(In Japanese, with interpreting Japanese into English)

Kazuyo Sejima (Japan)

Kazuyo Sejima studied architecture at the Japan Women's University before going to work for Toyo Ito. She launched her own practice in 1987. In 1995, she established SANAA with Ryue Nishizawa. Her own works include, House in a Plum Grove and Inujima Art House project. SANAA's main works include the 21st Century Museum of Contemporary Art in Kanazawa, Rolex Learning Center, EPFL, the Louvre Lens, and the New Museum of Contemporary Art. SANAA's current projects include the Grace Farms Project in Connecticut, USA, and the Bezalel Academy of Arts and Design in Jerusalem, Israel. In 2010 Kazuyo Sejima was appointed director of the Venice Biennale. And in the same year, Kazuyo Sejima and Ryue Nishizawa of SANAA were the recipients of the prestigious Pritzker Architecture Prize.

photo:Takashi Okamoto

Invited Talk (MCS)

Thursday, May 21, 8:30-9:15 (sola city Hall)

Multispectral colour imaging: Time to move out of the lab?

Jon Yngve HARDEBERG and Raju SHRESTHA
The Norwegian Colour and Visual Computing Laboratory
Gjøvik University College, Gjøvik, Norway

ABSTRACT

In this paper we present and discuss our recent research using three approaches for fast and cost-effective acquisition of multispectral colour images; using a stereoscopic camera with additional optical filters, using an extension of the traditional colour filter array beyond the conventional three channels, and using active LED illumination in conjunction with RGB or panchromatic area image sensors. An important goal for this work is to achieve faster and more practical solutions for multispectral colour imaging, paving the way for new application areas and more widespread use, beyond the scope of the resarch laboratories.

Jon Y. Hardeberg (Norway)

He is currently Professor of Color Imaging at Faculty of Computer Science and Media Technology, Gjøvik University College, Norway and member of the Norwegian Color and Visual Computing Laboratory. His current main research interests include multispectral color imaging, print and image quality, colorimetric device characterization, color management, and cultural heritage imaging.His professional memberships include IS&T, SPIE, and ISCC. He is the Norwegian delegate to Division 8 of the CIE.

Invited Talk

Friday, May 22, 8:30-9:15 (sola city Hall)

Neural Representation of Color in Visual Cortex

Hidehiko KOMATSU

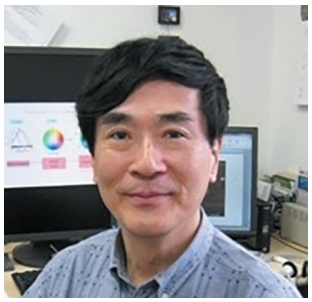
Division of Sensory and Cognitive Information, National Institute for Physiological Sciences

School of Life Science, SOKENDAI (The Graduate University for Advanced Studies)

ABSTRACT

To understand how the object color is represented in our visual system, we need to understand at least two things: how the wavelength composition of the light is transformed to the color signal and how the surface reflectance property of the object is represented in our visual system. Numerous attempts have been made to answer to the former question, and we now know that color signal is conveyed from the retina to the higher visual cortex along a specific visual pathway through several steps of signal transformation. Attempts to answer to the latter question have emerged only recently. These studies have shown that neurons selectively responsive to specific range of gloss exist in higher ventral visual area and that these neurons encode perceptual parameters of gloss. These two lines of studies in combination will shed light on how the object color is represented in our visual system.

Hidehiko Komatsu (Japan)



He is currently Professor of Division of Sensory and Cognitive Information, National Institute for Physiological Sciences, Japan. His current main research interests include neural representation of color in higher visual cortex, neural mechanisms of gloss perception, texture processing, and multimodal integration in material recognition.

He is currently project leader for a large research project "Brain and Information Science on SHITSUKAN (material perception)" funded by the Ministry of Education of Japan.

Judd Award Lecture

Thursday, May 21, 16:30-17:45 (sola city Hall)

On the dimensionality of the colour world

Françoise VIÉNOT

Centre de recherche sur la conservation (CRC, USR 3224)
Muséum national d'Histoire naturelle

ABSTRACT

Whereas, for colorimetric purpose, the three-dimensionality of colour cannot be circumvented and clearly refers to cone fundamentals, we examine situations where a reduced or expanded dimensionality could be experienced. Besides the case of individuals such as dichromats who suffer from a limited number of cone photopigments and enjoy two-dimensional colour vision, specific contexts or specific operations may require additional dimensions which could be supported by rod signals or melanopsin signals.

Françoise Viénot (France)

Emeritus professor, Muséum National d'Histoire Naturelle, Paris. Expert in color vision and appearance measurement, research on colorimetry, photometry, gloss metrics and LED illumination. French representative and former officer of CIE Division 1 (Vision), chair of CIE TC 1-36 "Chromaticity diagram with physiologically significant axes", vice-president of CIE-France. Newton medal (Colour Group of Great Britain) and Verriest medal (International Colour Vision Society).

Abstracts

Oral Papers

OS1-1

How Multi-Illuminant Scenes Affect Automatic Colour Balancing

Liwen XU and Brian FUNT
School of Computing Science, Simon Fraser University

ABSTRACT

The usual first step in automatic colour balancing of digital imagery is to estimate the chromaticity of the illumination. Although there are some recent exceptions (Beigpour et al. 2014. Gijsenij et al. 2013), most illumination-estimation methods assume that the relative spectral power distribution of the illumination is constant throughout the scene. However, many scenes contain multiple illuminants with differing SPDs, and we investigate the effect this has on automatic colour balancing. Somewhat surprisingly, the Gehler-Shi data set of 568 images, which is widely used in evaluating competing illumination-estimation methods, contains many images of multiple-illuminant scenes: for example, indoor scenes that also include a window through which daylight is visible. Each image in the dataset contains an Xrite/Macbeth ColorChecker that is used to provide a ground-truth measure of the illumination's 'colour'. However, since many of the scenes do contain multiple illuminants, a single such measurement cannot possibly represent the colour of all the illuminants correctly, but rather must represent some sort of compromise. We investigate how much of an effect this has on a representative set of illumination-estimation methods; namely, MaxRGB, Greyworld, Shades-of-Grey, Edge-based, N-jet and Thin-plate-Spline. We manually sorted the original 568 images into two groups according to whether the images were single-illuminant (subset A, 346 images) or multi-illuminant (subset B, 222 images). We then tested the various methods on the full dataset, and the two subsets. As expected, performance was generally better on subset A than on the full dataset since A satisfies the methods' single-illuminant assumption. Generally, the median errors reduced by 60%. Similarly, the median errors on subset B versus A increased by roughly 300%. Quite surprising, however, was the fact that the errors for Greyworld and TPS both were roughly the same whether on A, B or the full set.

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OS1-2

The Generalised Reproduction Error for Illuminant Estimation

Graham FINLAYSON and Roshanak ZAKIZADEH
School of Computing Sciences, University of East Anglia, UK

ABSTRACT

In a recent publication "Reproduction Angular Error: An Improved Performance Metric for Illuminant Estimation", British Machine Vision Conference (2014), it was argued that the angular error is flawed when it is viewed in concert with how the illuminant estimate is used. Almost always we use the illuminant estimate to make an image reproduction where the colour bias due to illumination is removed or reduced. It was shown that when a single algorithm was used to estimate the light for a range of illuminants where identical reproductions were produced that the angular error could vary widely (e.g. easily between 3 and 30 degrees). The Reproduction angular error introduced in that paper remedies this flaw by measuring the angle between a true white patch and the white that is reproduced when an illuminant estimate is made (and the colour bias due to this estimated light is removed from

the image).

In this paper we generalise the reproduction error to consider how well a range of colours are reproduced. We show how an illuminant estimate is used to map the colours in a Macbeth colour checker to reference lighting conditions. And, then we evaluate the reproduction using the mean CIE Delta E. We then use this new metric to compare different algorithms performances using our generalised reproduction metric. For the widely used 'Gehler' Colour checker data set there are small but significant changes in the rank order of a range of different algorithms. Significantly, the rank-order of the reproduction angular error is quite similar to that established with the generalised reproduction error. Based on our experiments we propose that the simpler reproduction angular error can be used as a proxy to our generalised metric to assess the performance of illuminant estimation algorithms.

OS1-3

Rank-Based Camera Spectral Sensitivity Estimation

Graham FINLAYSON and Maryam MOHAMMADZADEH DARRODI
School of Computing Sciences, University of East Anglia, UK

ABSTRACT

The spectral sensitivity function of a camera can be determined by lengthy and difficult measurements in the lab. Otherwise, they can be found through statistical inference, which is the focus of this paper. Under the assumption that a camera has a linear response, the RGBs recorded by the camera are linearly related to the spectral stimuli. Assuming the spectra reflected from a target are known, the spectral sensitivities of the camera can be found using linear regression. However, even small departures in linearity – the camera is not exactly linear as assumed - can significantly impact sensor estimation accuracy.

The main contribution of this work is to show how linear camera spectral sensitivities can be estimated even when the colour camera has a non-linear response. We begin by observing that almost all non-linear camera functions are monotonically increasing. That is, whatever the non-linear functions might be (gamma, camera curve etc.), the ranks of the non-linear RGB counts are the same as for their linear counterparts. Suppose that C_1 (λ)and C_2 (λ) denote the spectras of light entering the camera and induce the red sensor responses R_1 and R_2 where where R_1>R_2. Mathematically, 50% of all possible sensors S(λ) will integrate with the spectral difference ⟦C_1 (λ)-C⟧_2 (λ)to give a positive response and the other 50% of the sensors will give a negative response. The rank ordering teaches that only sensors inducing positive where the colour difference induces a positive response are are possible. Every pair of responses coupled with the corresponding spectral difference, splits the space where the camera spectral sensitivity might lie into two. That is, every pair-wise ranking defines a 'half-space' in which the sensor must lie. Of course, the spectral sensitivity of the camera must lie in the intersection of all the half-spaces defined by the difference spectra from all the response pairs. Remarkably, by applying this simple ranking argument, we have found small numbers of spectral stimuli (20 to 50) generally suffice to estimate the linear spectral response of a camera which may highly responds in a highly non-linear manner to light.

We evaluate the results of rank-based spectral estimation for two previously and rigorously measured cameras (Nikon and Sigma SD1 Merrill) using ground truth spectral data measured at National Physical Laboratory of London [1]. We also review some regression techniques proposed in the literature such as Tikhonov regularization [2] and quadratic programming [3]. Our results show that the proposed rank-based method provides estimated spectral sensitivity functions that are equally good as those returned by other state–of–the art spectral sensitivity estimation methods when camera response is linear. When camera response is non-linear, rank-based spectral estimation provides a step change in our ability to estimate camera spectral sensitivities.

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OS1-4

Comparing Colour Camera Sensors Using Metamer Mismatch Indices

Ben HULL and Brian FUNT
School of Computing Science, Simon Fraser University

ABSTRACT

It is well known that only a colour camera that satisfies the "Luther condition" [4] can provide colorimetrically accurate colour images. Of course, colorimetric accuracy is only one issue of concern, and not necessarily the most important one, in terms of overall image quality. However, there are many situations—for example, dermatological imaging or paint and dye applications—in which it would be desirable to have a camera act as an imaging colorimeter. The Luther condition requires the camera sensitivity functions match the human eye's sensitivity functions to within a linear transformation. The problem with this condition is that it is all or none. If there is not an exact match then how is the discrepancy to be measured? We address this question using the metamer mismatch volume index [3] and compare the indices obtained for the sensitivity functions of the 28 digital cameras Jiang et al. [1] measured. Logvinenko [2] describes a new method of computing the metamer mismatching that arises for a change of observer and proposes a metamer mismatch volume index as a measure of observer-induced metamer mismatching. Since the camera-versus-eye situation is precisely a change of 'observer' the method and index are directly applicable. Observer-induced metamer mismatching (sometimes called 'observer metamerism') refers to the fact two lights that induce an identical sensor response in one observer (i.e., match), may induce non-identical sensor responses in a second observer. The set of possible such responses defines a metamer mismatch volume, and an index defined in terms of this volume is what we use as a measure of the difference between a given camera and the eye. Previous measures of the difference between observers have been somewhat arbitrary. For example, Jiang et al.[1] use the mean CIEDE00 of the 1269 Munsell chips under D65, and the RMS difference in the best linear fit of the sensitivity functions to one another. We show that the relative rankings by these two methods are unstable and compare them to the rankings based on the theoretically sound metamer mismatch volume indices.

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OS1-5

Advanced Measurement Technology for Image Clarity

Hideo KITA and Shigeo SUGA
SUGA Test Instruments Co., Ltd.

ABSTRACT

Evaluation of object surface structure has traditionally involved the assessment of familiar optical properties known as Gloss and Haze. More recently, the optical property attributed to object surface structure or structural internal optical effects, have gained major importance because such property can vary, while the traditional properties of gloss and haze remain constant, and vice-versa. This optical property is known as Image Clarity. We designed a test apparatus to quantify this optical phenomenon, which exists in both reflection and in transmission mode; thereby permitting analysis of virtually all materials.

The apparatus contains an optical beam which consists of a collimated slit of light reflected from a surface, or passed through a film or filter, after which the beam is passed through a comb of alternating pass and stop bands and the resultant image is then projected on a detector. The pass and stop bands exist in five sets of different special frequencies to accommodate a large range of image clarity specimens;.i.e., those that have high Image Clarity to those that have low Image Clarity. Image Clarity is then converted to a numerical index whose values are high when the specimen reflects, or transmits the image clearly and is low when the specimen blurs the image. High Image Clarity

is a highly prized optical appearance property for many surfaces such as automotive enamel, plated surfaces, printed materials, glass, plastics and films. On the other hand, some surfaces require low Image Clarity in the presence of high transmittance. An example of this might be the glass surface of a liquid crystal display where low clarity reduces reflected glare from environmental light sources in the viewing area.

The article defines in detail the methodology of the assessment of the optical scan of the comb and the equations used in calculations of both the reflection and the transmission modes of the phenomenon. It goes on to report the correlation with visual assessments of multiple observers on multiple specimens in both modes of view. It is shown how Gloss and Haze may remain constant and Image Clarity vary in magnitude in both the instrumental assessment and the visual assessment of the observers, but the instrument's assessments correlate well with the observer's assessment. The phenomenon of Gloss and that of Image Clarity are independent of each other. Thus, assessment of Gloss is not enough if clarity is desired to be controlled.

A final section of the article deals with obtainable precision of the Image Clarity assessments. These show that both repeatability and reproducibility are excellent in both modes of view.

OS1-6

Painting by Numbers: Transforming Fields and Edges to Vectors

Carinna PARRAMAN, Paul O'DOWD and Mikaela HARDING
The Centre for Fine Print Research, University of the West of England, Bower Ashton Campus, UK

ABSTRACT

The theoretical and practical objective of this research is to gain a deeper understanding of how physical artworks can be created that incorporate both analogue (paint, ink, graphite) and digital (vector); and could be described as containing textural or 2.5D qualities.

Contemporary printing has evolved as a process that is capable of printing flat areas of colour, alongside text, blends of colour, photographic images. In the emerging 2.5D and 3D print market, there is now a requirement to develop methods that can reproduce textures that have the look and feel of, for example, brushstrokes of old master paintings, or create realistic embellishments on photographs. The conflict between texture and image is more apparent where there are contrasts, edge contours, or attempts are made to distinguish relief from a flat picture plane. The appearance of false shadows and edges tends to amplify these problems.

Texture is a visual attribute that enables us to distinguish the differences between materials (substances or substance out of which a thing is or is made), identify the structure and shape of objects, and discriminate edges in a complex pictorial scene. In order to gain an understanding to create verisimilitude with materials, we can study lighting techniques, drawing and painting techniques used by artists (Bayer, 2004; Hollman, 2004; Jordan, 1995; Constable, 2007) along-side scientists working on human vision and texture perception. Three main characteristics that have been identified as useful in determining the qualities of a surface texture: value, repetition and edges. (Landy, 1996; Klatzky, 2010) The paper will consider examples by artists who have explored or exploited these qualities in their work and how these qualities can be used to develop methods for image segmentation and alternative methods for driving computer numerically controlled (CNC) paths for lathes, plotters and printers.

In our search for an identification of what are the basic constituents to identify, classify and reproduce texture, (Marr, 1980) differentiates between image and representation, and the use of what he describes as primitives to describe a shape. There are two primary classes of shape primitive: surface based (2D) and volumetric (3D). Of special interest, volumetric primitives involve the spatial distribution of a shape and vectors to describe its dimensions, along with shading and texture gradients.

In previous research, the authors considered how by observing the brush strokes of painters, (Parraman, 2012; 2013) images are generated through the use of lines, modulation of similar strokes and a repetitive over layering of paint. Inspired by the meticulous painting methods by artists such as Van Gogh and Seurat, the objective for the experiment is to create a vector-driven painting machine that applies a brush loaded with paint to paper in a methodical and mechanical way, yet remain human analogous. Whilst a vector approach (digital format) is highly machine repeatable, the resulting individual painted brush strokes (analogue) are not. We study the creation of non-uniform but

harmonious painting effects across paper substrates through the actuation and placement of the brush, and the flow of paint.

We are developing a contemporary approach that is based on vector or .SVG (Scalable Vector Graphics), which provides a set of instructions to drive CNC paths. In software programmes, a vector path is a series of mathematical elements that describe a set of lines, curves, arcs, and a combination of all to form closed shapes. A path can be stroked to obtain different thickness or colours, or used as input for other elements such as pressure, gradients in height, and blends to include opacity and translucency. We consider a vector-based drawing philosophy as significant to gaining an understanding of alternative approaches which break away from pixels (digital screen resolution) and halftones (analogue print resolution).

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OS2-1

Perception of Colours Illuminated by Coloured Light

Shabnam ARBAB and Barbara Szybinska MATUSIAK

Faculty of Architecture and Fine Art, Norwegian University of Science and Technology (NTNU)

ABSTRACT

Colour is not the property of objects, spaces or surfaces; it is the sensation caused by certain qualities of light that the eye recognizes and the brain interprets. The colours of the environment influence our experiences of light and the need for lighting – and vice versa: the qualities of light are essential for our perception and experience of colour. Therefore, light and colour are inseparable. Recent studies put the spotlight on considering simultaneously both colour and light due to their importance for architecture and their effect on the quality of life of users as well as on the minimizing energy consumption in buildings. The interaction between light and colour might cause colour shift especially in interiors situated under different light sources having different colour temperatures.

In order to carry out comprehensive analysis about the impact of light on the colour perception, there is a need to merge qualitative and quantitative approaches; the strengths of both could provide the best understanding. Just the mixed methods approach, which associates both qualitative and quantitative evaluation of the visual environment have been used to answer the following question: How is the perception of colour influenced by the colour temperature (CT) of light? The light in this case is a mixture of direct light and light reflected from a coloured facade.

The model in the scale 1:10 was used; it allowed a comfortable observation of an outdoor facade as well as the interior. The experiment was carried out during the exhibition entitled "Colour in the city" at Trondhjems Kunstforening and it was sponsored by the Norwegian Research Council as a part of the so called "research day" activity.

A sample with the reference colour was placed in the first room having large window-like opening toward the street; 14 colour samples were placed in the adjacent room with no opening to the street but illuminated by the white light (6500K) from translucent ceiling. The visitors could deserve if and in which way the colour perception depends on the colour temperature of the light. The experiment has been repeated with three different facades, yellow, dark red and light blue, something that enabled testing of the impact of the colour of the façade. The visitors were asked to assess which of the 14 colour samples looks most similar to the reference colour.

The results show that both, colour temperature of light and colour of façade, have significant impact on the perception; CT has stronger effect. It was also found that the nuances shifts toward the same direction with the same colour temperature of light for each façade. A similar tendency was observed for the hue. The statistical analysis that is in process at the moment will result with trustworthy and precise results that we will be happy to present at the AIC-2015 conference.

OS2-2

Effects of Furniture Colour on Apparent Volume of Interior Space

Keishi YOSHIDA and Masato SATO
Division of Environmental Sciences, Kyoto Prefectural University

ABSTRACT

Since the concept of Minimalism had popularized, interior space of a house has become more compact than ever before. Therefore, it has become an important issue how to make interior space appear spacious. Color of interior components is one of the most successful methods to solve it. There are many psychological effects of color; advancing color, receding color, expanding color, contracting color and so on. It goes without saying that some of them play an important role in interior space. Color of a wall, a floor and a ceiling strongly influence on an apparent volume of a room. Some studies have been conducted to evaluate the effect of the wall color on the apparent volume of a room. As interior space is usually furnished, it is clear that furniture color must also influence on the apparent volume of a room. However, only few studies have conducted with regard to the effects of furniture color.

The purpose of this study is to evaluate the effects of furniture color on the apparent volume of interior space of a house.

A series of psychological experiments were conducted to evaluate the apparent volume of interior space using one-tenth scale models of the room measuring 2.4meters in ceiling height and 3.6meters in width and depth. A rectangular solid simulating a bed or a cabinet was placed in the scale model of the room. Colors used in the experiments were red, blue, brown, white, grey, and black. There were forty-two experimental patterns made up of combination of the six colors and the seven solids. The wall and the floor were painted in the achromatic color, N8. The magnitude estimation method was applied to evaluate the apparent volume of the room. A standard model simulating the room without the solid inside and a comparison model with the solid inside were presented side by side. Twenty objects were asked to look into each model in turn through a viewing aperture in the rear wall and to reply their apparent volume of the comparison model in comparison with that of the standard model.

Outlines of results are as follows.

1) It was found that the white solids made interior space appear more spacious than those of any other colors. On the other hand, the black, the red and the brown solids made interior space appear cramped.
2) As for the solids simulating a bed, the taller the height of the solid, the apparent volume of interior space becomes more cramped.
3) As for the solids simulating a cabinet, all solids except for the white solids made interior space appear cramped in accordance with an increase in their volume, while the white ones hardly made interior space appear cramped regardless of their volumes.
4) In case of the solids having the same volume, interior space placed the solids simulating a bed appeared more cramped than those placed the solids simulating a cabinet.

OS2-3

Ideal GRID Model for Color Planning of Living Space

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ABSTRACT

Color plays a key role in shaping human environments: the visual sense is an important part of human perception; it corresponds to the way people create and design their living spaces. In many cultures around the globe, different cultural traditions have made use of color for product applications of all parts of daily life, and matters of communication. Color has sometimes been described as a matter of individual perception and personal views, but this study claims to consequentially make use of color characteristics in the process of urban design and city planning. Based on Minah (2008), this research explores color as a key element in city planning, building on the previous proposal of an urban color system for the City of Taipei, Taiwan; which included a color survey, district and neighborhood color analysis, and an overall city color layout based on three different modes of color arrangement: The CIE Color model, the Chinese Five-Elements Theory, and the rainbow colors. An overall Grid Model for Color Planning is suggested that uses hue, saturation and values to arrange spatial elements in a systematic way, and can serve for urban color design in different parts of the world, mapping out the tools and procedures that are necessary to identify the ideal color system for different urban traditions and lifestyles. Cities are determining color identities related to the colors of traditional construction, or based on future-oriented tasks. Geographical, climatic, and cultural influences all add individual features to the basic functions of an established common infrastructure, creating a unique appearance of the urban living sphere. The proposed Grid Model for Color Planning of this research suggests to make use of the identical functions of communal infrastructure, recommending suitable color components for the existing, unique local and traditional, or modern exterior design elements, and strives to develop a coherent color concept which translates the unique city characteristics into a comprehensive color code. Following the Grid Model of Color Planning, it can be used in all parts of urban life, starting from small scale color analysis of the neighborhood, regarding wall painting or garden architecture, street lamps and guidance systems; proceeding to medium size color recommendations of urban districts, applying color to district directions, landmarks, bridges, etc.; towards large scale color application of the city's urban space, such as colored subway lines and other transportation systems, public buildings, and so on. This prototype can be universally applied to the demands of citizens worldwide, by integrating basic requirements of the community, but adjusting to the local or regional peculiarities. As the responsibility for such an important, long-term project must not be left to isolated initiatives, it should involve all public authorities and private parties concerned with the creation and design of urban color spaces: like the government, residents, architects, and others.

OS2-4

Case Studies of Color Planning for Urban Renewal

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ABSTRACT

In Japan, environmental color, especially façade color has been thought to be private one for long time, then, we have not made consideration for harmony of façade color. Because of this, Landscape Act was published in 2004 from the Ministry of Land, Infrastructure and Transport, which purpose is to make a beautiful landscape and streetscape, and make characteristics of each city and town. Since then, some streetscapes are getting better, but others are not.

We investigated each city's Landscape Planning, especially their color regulations. From these investigations, almost city has limitation of the color for the façade using Munsell Color System. I think the limitation of the color effects for only the historical city, but not for unique landscape.

So we research some unique case studies using color for the street scape.

First case study is Girona in Spain. 30 years ago, old buildings were renovated and at the same time, facade of the street was renewal and colored. The architect, Josep Fuses I Comalada, planned the color, which idea was from the façade color of the old city. Nowadays, there are many visitors to see the colorful streetscape of Girona. This case is the successful case study of renovated city using street color.

Second case study is our university's color planning for the student accommodation. We were planning for them for some years. This case study is the same situation as Girona, because

the buildings were renovated and at the same time, the façade were colored. We have heard that colored façade gives students cheers and students would like to live in. This case study indicated the importance of the color and one of the hint for renovation, because Japan has a lot of buildings like these accommodation which were built 30 or 40 years ago.

Third case study is our sign planning for the Tsukuba City in Japan. This case study is not facade color planning, but sign design, because we think the sign design also makes unique characteristics for the city. With their monochrome photos for the backside and "art posts" for the side of the signs, these signs have good effects to environment and unique character, and made differences from other cities.

Fourth case study is our bus color design for the Hitachi City in Japan. It is also not façade color planning, but it also made unique characteristics for the city though color planning for the bus and bus stops.

With these case studies, it was showed that the power of the color is not a little. We hope the power of the color will be used more for making each city more unique and beautiful.

OS2-5

Building Colours in Taipei – Taking Wanhua District as an Example

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ABSTRACT

Colours of urban buildings are an essential factor affecting the appearance of a landscape. Urban colours reflect a city's image and characteristics, and are related to the residents' feelings about their living environment. Due to the fast industrial development in cities of Taiwan, in addition to the lack of proper urban planning and the lack of regulations, landscapes in either urban or rural areas have become less and less attractive. As one of the most important visual factors in an architectural design, color can easily change the impression of a landscape. Unfortunately, there has not been an urban color system developed specifically for Taipei City using modern technologies of the CIE.

To address the issue, this study investigated the building colour usage in Wanhua District, one of the earliest developed regions in Taipei. There are a number of historical, old buildings in Wanhua District, providing valuable cues or tendency in urban colour usage in this area. Specific objectives of this study include (a) to measure Wanhua's building colours on a number of main roads, (b) to analyse any tendency of the colour usage using CIELAB system, and (c) to develop guidelines of urban colour planing for this area. The present research used the colour matching methods introduced by the Colour Planning Center of Japan, together with the NCS Colour Scan, a colour measuring device for collecting both NCS values and CIELAB coordinates.

Six main roads of the Wanhua District were studied in this research, including Zhonghua Road, Kangding Road, Wanda Road, Guilin Road, Bangka Boulevard and Xizang Road, resulting in a total of 421 colours measured. As a result, the CIELAB hue angle was found to have a range from 30 to 120 degrees. The lightness range was between 30 and 94. The chroma values were found to be fewer than 50. Most of the colours were warm colours, with high lightness and low chroma. The buildings in the north part of Wanhua District were found to be darker than those located in the south of the area, suggesting a tendency related to the historical background of the region. Guidelines of building colours for this area are proposed on the basis of the colour survey results and the recent psychophysical findings of colour harmony.

OS2-6

Pritzker Prize Laureates' Colour Preferences

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ABSTRACT

It is unquestionable that architects dress in black, that their models are usually white and that they manifest an incomprehensible love for concrete. Consequently, in the website of the Pritzker Architecture Prize, the profession's highest honor since 1979, the work of the laureates stands out for its colourless appearance. The reason why colour is not noticed at first might be because it acts as neutral, blending in with the composition.

For the purpose of this study it has been important to define "achromatic" and "neutral" in the context of architectural colour. According to colour theory pure achromatics contain no hue or colour, these include black, scales of gray and white. Neutrals or near neutrals extend to nuances of low chromaticity, as brown and tans. Applied to buildings, neutrals and near neutrals allow other tones to stand out as chromatic in the composition. Under this principle, it is possible to catalogue neutrals according to context.

The distance or scale of perception used in the analysis of examples focuses on the building as a whole three-dimensional element, considering the setting. The object of the study is a sample of projects by the Pritzker Prize winners. The range of work which composes the portfolio of the elite is vast. The criterion for the selection is oriented towards the colour aspect of the projects. Initially the sources were the 'works' tab and 'official website' tab of the awardees (if applicable) in the Pritzker Prize website. Later these were complemented by other internet sites and illustrated bibliography.

A general impression led to catalogue the architects according to their preference for colour usage. Four tendencies for colour usage were identified: colour (C), neutral (N), achromatic (A) and white (W). Each tendency, represented by some architects, has been commented.

In a former paper presented at AIC 2008 the concept of 'colouring mode' was explained as the manner in which colours are applied to buildings affecting the perception of form. According to the results, the colouring modes were: volume, surface, layer, structural (or syntax), decorative, neutralizing and white. The relation between colour tendency and preferred coloring mode by each Pritzker architect has also been commented in the present paper.

The results are represented in charts and graphs. Amongst these 37 architects, it is evident that sophistication in colour pairs up with high quality architecture. Although the evolution of material technology increases the potential of colour usage in building exteriors, colour as an essential design element is not the most common tendency. The study confirms the inclination of a group of outstanding architects for the subtle coloration of materials. Considering that, if from Philip Johnson to Shigeru Ban the colourless has been recurrent, colour abundance is not envisaged.

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OS3-1

Computing Tristimulus Values: An Old Problem for a New Generation

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ABSTRACT

Tristimulus values (TSV) form the basis of colorimetry. They are transformed to other colorimetric coordinates for industrial applications such as colour specification, colour quality control, colour difference evaluations, device characterization for cross-media colour reproduction and recipe formulation. Accurate calculation of TSV is highly desired by industry for open environment communication.

The International Commission on Illumination (CIE) originally defined the TSV in terms of the integrations. Unfortunately, the integrands involved have no analytical expressions. CIE made a step further from 1986 by replacing the integrations by summations at 1nm steps.

However, the problems remain. The SPDs for the CIE illuminants D65 and A are available at 1nm intervals. The CIE 1931 and 1964 CMFs are available at 1nm given by CIE. Differently, not all the available spectrophotometers measure the SRF at 1nm intervals. Most of them measure at 5, 10, or even 20nm intervals. CIE gives some guidance only for 5nm interval data, but has no precise recommendations for data with measurement intervals greater than 5nm. Thus, in practice, various approaches have been used for computing TSV, which can lead to a big discrepancy between two different methods from the same set of spectral data, which can cause problems with various industrial applications. For example, one fashion designer asks a company for dyeing the fabric by providing a spectral reflectance data rather than a physical sample in order to save time and the cost. The requirement for the reproduction is less than 0.5 (for example) CIELAB colour difference units. If they use different methods for computing TSV, it is highly possible that the dyed fabric might be rejected though the company thinks the requirement is satisfied. Another example occurs with the recent rapid development of multimedia technologies and is with the cross media colour reproduction. In cross media reproduction chain, both the source and destination devices are characterized, so that the device dependent colour spaces are linked to the device independent XYZ space. If the computational methods for computing XYZ are different between the characterization processes of source and destination devices, it cannot be expected the reproduction will be accurate. Hence there is a great demand from industry applications for a unified method for accurately computing the TSVs for the best agreement between laboratories, which led to the formation of CIE TC 1-71 on Tristimulus Integration during the 26th CIE Session in Beijing, 2007.

In this paper all available methods such as CIE recommendations and ASTM weighting tables, Oleari method, Li Luo and Rigg method together with the newly developed LWL (least square method) are compared and it is found that the LWL method performs the best among all methods for any measuring interval length. Therefore, it is proposed that the LWL method should be used for computing tristimulus values. Detail results will be reported in the full paper.

OS3-2

Variability in Colour Matches between Displays

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ABSTRACT

The variability between colour matches made by different observers on displays is a concern which has been addressed in several previous studies. Inter-observer variability in perceived colour matches was investigated in an experiment in which 21 observers matched a series of test colours, with the reference stimulus on a CRT and the test stimulus on an LCD display. Reference and test colour patches with a 2 degree angular subtense were presented on adjacent displays with a separation between reference and test stimuli of 7cm, and with an opaque black mask covering the remainder of the display screens. The first reference colour was a mid-tone neutral gray, followed by nine chromatic colours. Observers adjusted the test colour to produce a perceived match to the reference, and the resulting colours were measured with a Minolta CS-1000 telespectroradiometer.

Measured spectral radiances were converted to XYZ using the CIE 1931 Standard Colorimetric Observer, such that the Y tristimulus value corresponds to the luminance of the stimulus in candelas/m2. The data were converted to CIELAB, using the reference display white point as the illuminant. The results showed significant differences in the matches made by different observers, with an average CIELAB 1976 colour difference from the reference of 19.5 and the inter-observer variability (expressed as the mean colour difference from the mean, or MCDM) of 10.4. There was considerable variation in results for the different test colours, with the average colour difference from the reference ranging from 10.6 to 27.2 DE and the MCDM ranging from 2.4 to 21.2.

When considered in u', v' chromaticity, the differences between reference and test colours, and the inter-observer variability, were much smaller. This suggests that observers had greater difficulty in

matching the absolute luminance of the test to the reference stimulus than in matching chromaticity. Some systematic differences between reference and test colours were seen, with matches being on average brighter and more purple.

This study confirms the significant inter-observer variability in colour matches found in other studies. The absence of a white for visual adaptation in the experimental set-up may have contributed to difficulties in making the matches, and may also make the choice of reference white in the conversion to CIELAB less determinate.

OS3-3

A Comparison Study of Camera Colorimetric Characterization Models Considering Capture Settings Adjustment

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ABSTRACT

The colorimetric characterization of digital camera is of fundamental importance for its scientific applications such as image based colorimetric measurement and color communication. The mappings from camera RGB device-dependent signals to CIE XYZ device-independent values defined by conventional characterization models can yield reasonable color accuracy. These models, however, which require camera capture settings to be fixed from sample training to practical measurement, do not make full use of the dynamic range and adaptability of the digital camera. Whenever the capture settings used in practical measurement are adjusted, the sample training process has to be performed again according to the changed settings. To overcome this inconvenience, a correction procedure was carried out in this study to compensate the error resulted from the changes of camera capture settings. This correction procedure utilizes the mappings derived from conventional characterization models, but it introduces two processes, i.e. equivalent transformation step and scale factor step, based on the imaging system. The equivalent transformation step builds the bridge between the different capture settings such as ISO sensitivity, aperture and shutter speed, while the scale factor step is used to reduce the error caused by the nonlinear relationship between RGB and XYZ. Thus, once the transformation from RGB to XYZ is solved based on conventional characterization models, the RGB signals of images with different capture settings can be transformed to the corresponding XYZ tristimulus values without any more training. To investigate the performance of this compensation comprehensively, four kinds of widely-used characterization models were employed in this correction procedure as the mapping technique, including look-up table (LUT), polynomial regression, artificial neural networks (ANN) and support vector machine (SVM). In the experiment, a light booth of GretagMacbeth SpectraLight III was used to provide stable lighting environment, in which a GretagMacbeth DC color chart was placed as the test samples. And a Nikon D3x DSLR camera was adopted to obtain the different RGB values under various capture settings. The results show that the color accuracy of all the four conventional characterization models deteriorates badly as the gap between the settings of training and testing becomes wider. On the other hand, the color differences achieved by the correction based on the four different characterization models remain at a satisfactory level as the capture settings being changed, for which it is noteworthy that ISO sensitivity higher than the maximum of the standard ISO range (100-1600 for Nikon D3x) and exposure value out of the dynamic range of the camera should be avoided because of the low signal to noise ratio. Herewith, it is recommended to alter shutter speed when the lighting intensity varies. By comparison, it can be concluded that this correction procedure for adjustable capture settings is applicable to different kinds of conventional colorimetric characterization models.

OS3-4

Evaluation and Analysis of *YUTEKI-TENMOKU* Visual Effect on Traditional Ceramic Applied Gonio- Photometric Spectral Imaging and Confocal Type Laser Scanning Microscopy

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ABSTRACT

TENMOKU ceramics were produced in Zhejiang Province of Chinese Southern Sung Dynasty, and it is considered to be brought to Japan by Zen priest around 800 years ago in Kamakura period. Especially, these were prized in Japanese traditional tea ceremony and one of the sought-after item in *CHANO-YU*. *YUTEKI-TENOMOKU* is kind of these type ceramic, and many traditional tea bowls were designated a national treasure. The glaze was included a lot of iron ingredient, and the visual feature is oil droplet pattern on black ground of the ceramic surface.

These pattern was appearance by precipitation of iron crystalline and one of the important optical manifestation, that is gonio-apparent and anisotropic color. It is necessary analysis correlation between changing of color appearance with various optical dimension and orientation of iron crystalline in glazing layer to clarify characterizing about these ceramics color appearance.

In this study, the flat shape plate of *YUTEKI-TENOMOKU* ceramic was prepared with oxidation firing, and the applied glaze was composed feldspar $(Na,K,Ca,Ba)(Si,Al)_4O_8$, lime $Ca(OH)_2$, silica stone $Si(OH)_4$, kaolinite $Al_2Si_2O_5(OH)_4$, and red iron oxide Fe_2O_3 ingredient.

The detail measuring way of color was applied the gonio photometric spectral imaging system which was composed liquid crystalline tunable filter, white LED illuminant, and Peltier cooling monochrome CCD image sensor. Illuminant direction was 15, 45 and 75 degree from normal direction, and detect direction was normal against sample. To get highly accurate gonio-photometric reflectance spectrum and imaging information, each wavelength sample images were compensated by measuring of black/white lattice pattern to sense small shift amount of x and y direction before measuring ceramic sample.

Also the three dimensional measuring way of iron crystalline distribution in glazing layer was applied confocal type laser scanning microscopy, and model VK-X100 made by KEYENCE was used. This microscopy was applied laser scanning technology, and allowing three dimensional reconstructions of topologically complex object by computer calculation, and can be sense interior structure with images of non-opaque specimen.

As the result, distribution in CIELAB color space calculated from measured spectral image of each illuminant angle was different. Especially, image of 15 degrees angle had wide distribution of L* direction by metal reflection. On the other hands, images of 45 and 75 degrees angle were narrow distribution profile and disappeared metal reflection. *YUTEKI-TENMOKU* has various visual effects depend on optics dimension. And microscopy observation was succeeded clearly getting three dimensional orientation information of metal crystalline reflection surface. The benefit of combined with gonio-photometric spectral imaging and confocal type laser scanning microscopy analysis way was shown in this study. This imaging technology was quite useful for traditional ceramics characterizing.

OS3-5

Measuring Skin Colours Using Different Spectrophotometric Methods

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ABSTRACT

The topic of measuring skin color has long been extensively studied due to the strong interests from the photographic, digital imaging, cosmetic, medical applications. However for the various

applications, the measuring methods and objectives of study are very different. For example, the contact method like spectrophotometer has been widely used for medical application such as to reproduce colours for graphic applications, to detect skin related diseases, etc. The non-contact method has been used for the appearance related application such as cosmetic, Chinese medicines, skin lighting. The results from both methods could be very different. In order to acquire standard in this regard, some basic study should be done. However, in some of the databases such as SOCS, defined by ISO, the measurement results were mixed.

In the present study, four different measuring methods, five different measuring devices and tools were used to measure human skin color. They include none contact method (a digital camera, a skin color chart for visual assessment, aspectroradiometer), and contact method including 2 spectrophotometer, which had different geometries: 45°: 0° and di: 8°and also different apertures 4.5mm and 9mm, respectively. A D65 fluorescent simulator was used as ceiling light to illuminate the subject for visual assessment.

In total, 51 subjects from four skin groups participated in the experiment: 21 Chinese, 10 Pakistanis, 10 Caucasians and 10 Africans. For each subject and each method except the visual match, eight parts of the body were measured: forehead, right cheek, left cheek, hand back, fist back, palm, inner forearm and outer forearm. For the visual match against a Pantone skin chart, three different observers measured only the forehead and the right cheek separately. In total, 408 data were obtained.

The data were analyzed in respect of the color shifts between different parts of the body, between two genders,between difference nations,and between different measuring methods. The results showed that the facial skin color (forehead, right cheek and left cheek) had a smaller hue angle (redder) than color of the arm (hand back, fist back, palm, inner forearm and outer forearm). Clear trends were identified from the experimental results, i.e. the more the skin is exposed to sun such as forehead, the chroma value of the skin color will be higher and the lightness value will be lower than the area such as inner arm, indicating an increase of ‘saturation’ or ‘depth’. There is also systematic difference between female’s and male’s skin colours, i.e. female colours are slightly pinkish and lighter than males’. Different measuring methods’ results show very similar patterns and the major difference is in the region of long wavelength of their spectrals.

Finally, Principle Components Analysis (PCA) method was used to analyze all the reflectance data and the results indicated that three primary components can achieve very high accumulative contribution. And it implied that it is possible to reconstruct human skin spectral reflectance using only one single model.

OS3-6

Assessing Light Appearance in Shopping Mall

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ABSTRACT

Lighting appearance in rooms is of great importance for lighting research. However, most of the researches were carried out in carefully controlled compartments or rooms, like Li et al., Rea and Freyssinier, Ohno and Fein. In order to verify the conclusions drawn from earlier studies, the lighting appearance of 20 different shops in two representative modern shopping malls in the city of Hangzhou, China, were investigated. The aim was to study the lighting appearance in real environment and eventually to establish an imaging-based method for quantifying the visual perception in real living environment, i.e. image processing software from image, via calibration, visual modelling and prediction.

Different types of shops were visited to look into the lighting ambiance for different categories of stuff like costume, shoes, cosmetics, jewelry, watches and food products. Both physical measurement and psychophysical assessment were carried out simultaneously by measuring a 1.2×0.8 m^2 white board from a distance of 2 meters. Firstly, an image was captured by a Canon digital camera with a Macbeth ColorCheck Chart on the surface of the white board. The lighting parameters,

including luminance, correlated color temperature (CCT), spectral power distribution (SPD), u'v' coordinates, were measured by a PhotoResearch PR670 spectroradiometer. In the visual assessment experiment, three normal colour vision observers estimated the brightness, colorfulness and hue composition of the scene appearance in the shops using the magnitude estimation method.

The data of different ambient scenes in shopping malls were analyzed. It was found that the public spaces like the cashier, corridor and entrance, LED lamps have been widely used because of its great advantages on long life and energy saving. However, the majority of branded stores still keep using conventional lamps such as fluorescent lamps and few tungsten lamps for illuminating the merchandise in consideration of higher colour rendering and special lighting effect. For the physical measurement, the vertical luminance values were found in the range 100-200 cd/m^2 at the height of 1.2m. The correlated colour temperatures (CCT) in the shops was in the scope of 2500K to 4000K, which create a warm and comfortable feeling. One jade jewelry shop is an exception to use a high CCT about 6700K which is a typical lamp used in the trade.

The experimental results confirmed some of the earlier findings but also have their own features. With similar luminance, a light with higher CCT makes the room to be brighter than that with lower CCT. However, as the lightness varies from shop to shop in practical environment instead of being constant, higher CCT is perceived to be more yellowish but not occur to be brighter in our experiment. Surprisingly, higher luminance values do not correspond to be brighter visually in the scope of 100 to 200 cd/m^2 because CCT has a big effect, especial when CCT is below 3000K. CIECAM02, a colour appearance model for predicting object colours, was also used to predict visual perception in a room. It was found that CIECAM02 predicts well in terms of colorfulness and hue composition except brightness in real rooms. An extension equation was used to adjust the brightness scale of CIECAM02 and it turned out to confirm Li's method.

OS4-1

Pupillary Light Reflex Associated with Melanopsin and Cone Photorecetors

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ABSTRACT

Introduction:
A recent study has shown that intrinsically photoreceptive retinal ganglion cells (ipRGCs), which contains photopigment melanopsin, project to the pupillary control center in the pretectum. The ganglion cell is photosensitive and receives signals from classical photoreceptors. Although both cone and ipRGC signals contribute to pupillary light reflex, it is difficult to investigate how these signals are summed. The challenge stems primarily from the need for selective stimulation of each photoreceptor type. Here, we independently stimulated human ipRGCs and cones, and investigated how signals driven by ipRGCs and cone-mediated signals contribute to the pupillary control mechanism.
Methods:
A four-primary illumination system that enables independent stimulation of each photoreceptor class (Tsujimura et al., 2010) was used to present the following three types of test stimuli: one varying L-, M- and S-cone stimulation only without change in stimulation of ipRGCs (LMS-cone stimulus), another varying radiant flux of the stimuli without change in spectral composition which reduced/increased the radiant flux uniformly at all wavelengths (Light flux stimulus) and the other varying ipRGC stimulation without change in stimulation of L-, M- and S-cones (ipRGC stimulus). The intense test and adapting fields which minimized the involvement of rods were used. The test and adapting fields had a CIE coordinate of (0.57, 0.36) and a luminance of 1,221 cd m−2 for the test field and 355 cd m−2 for the adapting field, respectively. The test stimuli were generated based on the cone and ipRGC spectral sensitivities of which the peak wavelength is 493 nm. The transient pupil responses to these stimuli were measured.
Results & Conclusions
It was found that the transient pupil response to ipRGC stimuli had a longer latency than the responses to the LMS-cone and light flux stimuli. The results indicate that we successfully demonstrated the

pupillary response to ipRGCs under conditions where ipRGCs are isolated in humans. The longer latency suggests that signals from ipRGCs in the non-image forming pathway travel more slowly than that of the LMS achromatic mechanism in the image forming pathway.

OS4-2

Experimental Research on EEG Characteristics in Red, Green, Blue, and White Color Space Consequent on the Degree of Depression

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ABSTRACT

Color is the most influential environmental factor on us, and it is connoted in space or a things, to which we are exposed. These days, color sometimes remedies diseases like depression or stress using the influence of color on a human psychology. There have been research works on depression and color, but it's actually rare to find the research work on the analysis of EEG in a life-size Mock-up state. Hereupon, this study is intending to make a comparative analysis of EEG characteristics in a life-size Mock-up color space using the most widely used BDI-II(Beck Depression Inventory-II) among the self-report type questionnaires that have been developed to measure the depression scale.

As for the experimental environment, this study installed 600*600mm size D65 standard illuminant in the space of 1500*1500*2400mm size Red room(5R 4/14, S2070-R), Green room(7.5G 5/8, S2555-G), Blue room(7.5BG 5/8, S2555-B30G) and White room(N9.5, S0500-N), respectively and set up interior illuminance as 1001x.

In addition, this study compared the results of EEG measurement by classifying the subjects in their 20s ~30s as a normal group and a depression group according to BDI-II Depression Self-Diagnosis results.

As a result of this research, it was found out that there appeared a difference in EEG indicator in color space according to the depression scale. Thus, this study was able to learn that there appeared a difference in EEG indicator in color space consequent on the degree of depression, which is interpreted as the fact that th degree of depression has an influence on EEG. In order to generalize the experimental results, this study is going to conduct a follow-up experiment by composing the age group of the subjects more diversely.

OS4-3

Hue-Tone Representation of the Nayatani-Theoretical Color Order System

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ABSTRACT

Hue-tone representation of the Nayatani-Theoretical (NT) color order system is proposed. The NT system is a new color order system developed by Nayatani based on his color-appearance and color-vision studies in 2003. The system has several unique features; It consists of six primary colors, red (R), green (G), yellow (Y), blue (B), white (W), and black (Bk). It adopts three opponent-colors axes, not only red-green (R-G) and yellow-blue (Y-B), but also white-black (W-Bk); It has the reference gray in the center of its color solid and clearly defines the grayness attribute which is not defined explicitly in many other color order systems such as Munsell system and NCS. The NT system has color attributes whiteness w, blackness bk, grayness gr, chroma C and hue H. The same color attributes [w, bk, gr, C] with different hues [H] have the same perceived lightness, the same degree of vividness, and also the same color tone. This is the primary feature of the NT system, that is, the inclusion of the color tone concept. However, its tones are not explicitly stated in the NT system so far. Therefore, in this paper,

we introduced the categorical tone representation to the NT system with hue divisions. This makes the NT system more useful for various purposes. The tone concept has been widely used in the artistic fields of painting and color design from the old days. The NT tone categories, for example, can be used for selecting the color combinations in those artistic fields. In the color science field, the color stimuli extracted based on the tone categories are frequently used in a wide variety of sensory testing of vision. The NT tones are also suitable for such scientific purposes, because its tones are derived based on the color-appearance studies and have well-defined colorimetric values. This colorimetric background will be of help when analyzing the sensory data.

OS4-4

Colour Appearance in the Outdoor Environment

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ABSTRACT

Existing colour appearance models such as CIECAM02 have typically been developed using displays, prints and other media. Nevertheless, these studies have been limited to indoor conditions. It has been unclear whether or not these colour appearance models based on indoor experimental settings also apply to the outdoor environment. There is much greater variation in the luminance of light source outdoors (i.e. the day light) than indoor lights, due to unpredictable weather conditions. The human visual system has considerable ability to adapt to such variation. More importantly, the illumination level is way higher in the outdoor environment than indoor lighting. Colour applications for indoor conditions are quite different than those for the outdoor environment. The latter include outdoor colour measurement which is essential for architectural colour design and urban colour planning.

Several issues need to be addressed properly before a colour appearance experiment can be appropriately carried out outdoors. First, the selection of the experimental location is crucial. There should be no glare within visual range of the observer, so that the white tile serving as the reference white is the brightest in the viewing field. Moreover, outdoor luminance varies all the times due to the position of the sun and the weather conditons. To overcome these issues, all observers in the study must assess colour appearance of each colour sample at the same time, in the same place. And this was exactly how the present study was carried out.

As described above, the experiment was conducted outdoors on a sunny day by all observers at the same time, in the same place, where there is no glare in the observer's viewing field. The reference white, the reference colourfulness and each test colour patch were all placed on a vertical panel covered with a medium grey cloth. The test colours included 42 colour patches selected randomly from the Practical Coordinate Color System (PCCS) to cover a wide range of hue, lightness and chroma. A total of 16 observers with normal colour vision were asked to estimate the lightness, colourfulness and hue for each test colour. During the experiment, for each test colour, the reference white, reference colourfulness and the test colour itself were measured in terms of the tristimulus using a Konica Minolta CS-100A, a portable colour meter.

The experimental results show high correlation between the visual data and the predicted values by CIECAM02 in terms of colourfulness and hue. The perceived lightness, however, was found different than those predicted by CIECAM02. As suggested by the experimental data, the visual system seems to be more sensitive to the variation of lightness while in the indoor environment with an average surround condition. However, the visual system seems to become less sensitive while in the outdoor environment at a high luminance level. This suggests a strong effect of the luminance of environment on the visual system in terms of perceived lightness.

OS4-5

Color Play: Gamification for Color Vision Study

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ABSTRACT

Color is an important aspect in our daily lives and essential for discriminating objects. In the current study, we investigate "gamification" as a novel approach to improve the analysis of human color perception in psychophysical studies.

Most psychophysical studies are prune to limitations: due to their complex setup, the number of subjects is often small and not representative of the population; highly controlled environment affects the subjects' natural response and can cause individuals to alter their behavior due to the awareness of being observed. Often subjects find the task boring and long which not only decreases their motivation but also focus. This would lead to observations that may not be representative. Increasing the number of subjects or repeating the study elsewhere or by others is often not straightforward and very costly.

Our goal is to investigate the intuitiveness and ease of color matching and color mixing tasks in different color spaces. We do this through gamification, where we have designed simple color mixing and matching game, which is relatively low cost and simple to maintain and operate. The equipment consists of 4 Philips Hue color light bulbs, the Playstation3 Move controller to be able to interact with the game, and a monitor. Observers are asked to use the controller to adjust each color channel in order to create a resulting color (shown in the fourth bulb) that should match with the reference shown on the monitor. In our experimental work we investigate the widely used RGB and HVS color spaces.

These games engage both children and adults in experimenting with different colors and color spaces in a fun and casual setup. Through these games, the users would learn about different color spaces. The games also collect anonymous data about how observers mix colors. An important aspect of such setup is getting access to a large number of subjects (from different age, gender, and ethnical group) volunteering to participate in for example science centers around the globe.

The main purpose of our game-play framework is to take color mixing/matching task out of the controlled laboratory environment and bring it to the context of everyday life. Such study would help us analyze people's relation with color spaces based on practical scenarios like finding the desired color composition for a room, a graphic design, website, advertisement, arts, games, and etc.

The results of a supervised and controlled experiment indicate that HSV is a more intuitive color space as the naïve subjects were faster in mixing colors compared to RGB. On the other hand, the subjects performed similarly in both color spaces based on their unanimity (inter-observer variability) and accuracy (average color distance to the groundtruth). Results also indicate that subjects matched more accurately the luminance compared to chroma. In an unsupervised experiment, subjects were faster in HSV, but more accurate mixing in RGB. Qualitative results from questionnaires evaluating user experience indicate that on average participants had a positive experience with the game.

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OS4-6

Using Visual Illusions to Expand the Available Colors for Making Mosaics

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ABSTRACT

Mosaic is an ancient art form of creating images by arranging pebbles, small pieces of ceramics, or other colored material called tesserae. One of the challenges in creating mosaics is the limited number of colors of the material. In order to create the desired colors that do not exist, mosaic artists have to make great efforts to learn principles of color mixture of tesserae which is not always intuitive. In this research, we attempt to look for other possible solutions for increasing available colors by applying two different visual illusions, Craik-O'brien-Cornsweet illusion and neon color spread

illusion, to the mosaic design. To find out the optimal set of parameters to maximize the effect of illusion, we designed a series of computer-simulated experiments to examine how parameters such as the size of tesserae, the width and the color of grout, and the slope of luminance grading affect the magnitude of these two illusions. The results show that the magnitude of Craik-O'brien-Cornsweet illusion is remarkably stable across all manipulated values of parameters. The neon color spread illusion, by contrast, is sensitive to scale of tesserae, and width and color of the grout lines. Increasing the width of the grout lines will enhance the neon color spread illusion while increasing the size of tesserae would weaken the illusion. The magnitude of neon color spread varies with hues of grout. Green grout generates the strongest illusion, followed by red, blue and yellow grout in that order. We also create an Ehrenstein figure with ceramic tesserae according to the results of the experiment and the illusion effect of this physical version supports the conclusion of the experiment of neon color spread illusion.

OS5-1

Are There Ugly Colours?

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ABSTRACT

For centuries artists have searched what kind colour combinations are harmonic, affording aesthetic pleasure to viewers. In Finnish art education teaching of colour relationships is still largely based on traditional notions of harmony. Many kind of theories have been formed of colour harmonies. We have seen endlessly beautiful, harmonic paintings, all kind of visual pictures in different media. Colour harmony based on abstract and formal ordering, unity, balance or pleasantness has to a large extent ceased to motivate artists (Arnkil 2013).

What does the opposite, disharmony, mean? If harmony affords aesthetic pleasure and "tranquillity of mind", does disharmony afford aesthetic discomfort and "disturbance of mind"? How can we create aesthetic discomfort?

This oral presents with many illustrations how students investigate and express intentionally their conception of disharmony. Their task was to create as disharmonic or "ugly" a painting as they can. It always turns out that they have never taken this kind approach before. Disharmony is defined as the opposite of harmony. It raises conflicting feelings when there is no visual hierarchy and equal "visual powers" are fighting with each other causing frustrations, aesthetic discomfort.

First reactions of the students after receiving instructions to the exercise "Disharmonic painting" are always disbelief and laughter. They think "disharmonic painting" is very easy and fast to do. In general they begin to paint with the "ugly colours", with colours and compositions they hate. The painting processes of disharmony are very interesting to follow as a teacher.

The target of ugliness in the meaning of disharmony is, generally speaking, difficult for the students to achieve. Is it possible to achieve disharmony at all? They notice that disharmony is even more difficult to express than harmony. It is also a kind of paradox that when they try to create chromatic harmony and beauty they fail ,whereas when their primary task is to create disharmony they achieve something very interesting, fresh and good looking, something they would have never have achieved, had they worked in the accustomed manner.

In the end the students learn to understand that harmony and disharmony are equally important in art. Disharmonic elements, anomalies, are very important to make visual tension and attractiveness. With both harmony and disharmony highly interesting contrast can be created. The students learn also that there are no ugly colours in the absolute meaning: their ugly colours turned out be the opposite. It is very interesting to share and discuss notions of what is disharmony and ugliness. What constitutes them in the picture?

OS5-2

A Novel Experience in Color Teaching: Master in Color Design & Technology

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ABSTRACT

Experiences in the teaching of color are central to the AIC community. The difficulties in this goal are due to the intrinsic multidisciplinary nature of color and to its many different possible applications and related technologies. Moreover, colors have emotional, cultural and symbolic valences and designing with color can sometimes look like a matter of personal preference.

In order to be able to teach all aspects related to color and make the student experience them, Università degli Studi di Milano and Politecnico di Milano have organized in the academic year 2013-2014 the first edition of the Master in Color Design & Technology with the aim of providing in-depth training in the complex field of color design and color technology. The master aims at forming professionals able to manage the technological and design complexities of using color in creative and industrial processes and in many application domains: from industrial product design to interior architecture, from communication to fashion and entertainment, and even in designing the urban environment.

The master's program is organized in two separate learning phases.

The first phase is divided in four modules. In the first one the culture of color is introduced, starting from its history, and then investigating the aspects of perception that are the basis of its complexity. The second module is dedicated to the color physics, optic and measurement fundamental and color atlases. With the diffusion of new technologies, more and more aspects of communication and color reproduction are becoming digital, thus in the third module, color imaging, the theoretical and practical fundamentals to manage, display and reproduce digital color contents on different media are provided. Finally the fourth module explores the profession of color designer through examples and case studies, in various professional contexts.

The second part of the master consists of five project works that are designed to put students in a position to verge what they have learned in the fundamentals in five scenarios of typical color design. The first module is about communication, where students are asked to interpret the color in the context of publishing. The second module deals with fashion design, while the third module focuses on the chromatic planning for innovative retail spaces designed to ensure a harmonious relationship with the values coming from the brand and the corporate identity. The fourth module on product design has the purpose to acquire methods and operational tools in order to design and develop proposals for the chromatic industrial product. The fifth module theme is the relationship between the color in urban spaces and the meanings of the human interactions that take place within it. The discussion focuses on the aesthetic upgrading of buildings in modern construction, to solve their visual impact.

At the end of all these modules, students are called for an internship in one of the companies or research centers related to the master. Among them we cite Barbieri, Barco, Boero Group, Ceramica Vogue, Clariant, Flint Group, Gmg Color, Konica-Minolta, Lechler, Mantero, Materis Paints, Missoni, NCS, Oikos, X-Rite.

OS5-3

The Ambiguous Term of "Saturation"

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ABSTRACT

Ambiguous use of colour terms creates misunderstandings in the colour classroom, among professionals and in customer services. One obvious example is the term saturation (German Sättigung, French saturation, Spanish saturación). In everyday language and in the vocabulary of painting saturation refers to the "intensity" or "vividness" of a colour. In this respect it is approximately equal to NCS chromaticness and Munsell chroma.

Colorimetric language, however, distinguishes between saturation and chromaticness: “Chromaticness is an absolute measure of chromatic content of a colour regardless of its brightness, while saturation is a measure of the chromatic content of colours of equal brightness” (Kuehni 1983). To add to the confusion, also the words chromaticity, purity and colourfulness are used as terms referring to more or less the same thing, the strength or vividness of colour, but each with its own scientific definition and set of parameters.

The most confusing use of the term saturation is presented as part of the NCS system. According to the definition given in the NCS atlas, colours that lie on a straight line from NCS black (S) possess equal saturation; NCS-saturation is defined as the relationship between chromaticness and whiteness. Thus NCS-saturation does not (and does not claim to) refer to “vividness”, but instead denotes a colour property that is distinctly different from the generic meaning of saturation. However, in their comprehensive scientific presentation of NCS (Color Research & Application 1996), Hård, Sivik and Tonnquist do not mention saturation although they present similar “dual qualities” namely deepness and clearness.

The concept of NCS-saturation is not perceptually consistent, but rather a mathematical play with the numerical values of abstract parameters. For example, in the case of nearly black colours that can barely be distinguished visually, the NCS-saturation varies between zero and infinity. Therefore this definition is problematic, whatever name is given to this NCS parameter. Colour gradients from full colour to increasing blackness can be perceived in natural scenes with light and shadow, and in art and photography the depiction of shading of e.g. round objects is approximately similar to the series of colours along the line of NCS saturation. This, however, does not justify NCS-saturation as a theoretical concept. To conclude, we suggest that the misleading concept of NCS-saturation is abandoned.

OS5-4

Colour Education and Real Life Colour

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ABSTRACT

In this paper we address three problems of colour education: 1) The idea that colour education must base itself on simplified cases, as it is seen as impossible to analyse complex perception. 2) The consequent formulation of a traditional “colour knowledge” that is too abstract to relate to our real life experiences. 3) The misunderstanding that subjective experiences are valid only for the experiencing individual.

1) In real life, colour exists in a complex spatial context, which is visually understood through our perception of light. It is possible to rationally describe and analyse colour within this complexity, but this requires other tools and concepts than those used in traditional colour education. People have a great tacit experience of colour and light in real life, and colour phenomena become clear and comprehensible only when they are discussed as part of a living everyday context, which by nature is spatial.

2) In most cases of colour education, colour is treated in a simplified way that does not relate to our every day experiences. Thus the pedagogical problem is not too high a degree of complexity, but the opposite. Colour is treated as separated from everyday life, either as something extraordinary and exceptional, deviant, strange or amorphous, or - quite contrary - abstracted to simple relationships between colours as such. Without connection to the world around, colour phenomena are to be experienced as something mysterious, and it is not made clear how “colour knowledge” is relevant in designing professions or in understanding our visual world. This could and should be altered by formulating educational programs that treat colour and light together, as interacting in a spatial context.

3) It is true that sensuous experiences are by their nature subjective, but the basic perceptual and mental conditions are functionally equal to all of us. This means that our experiences are largely inter-subjective, and thus valid far beyond the individual.

The book “Colour & Light. For humans – in a spatial context” is written in interdisciplinary collaboration and addresses its subject from many starting points, with the basic understanding that human experience is complex and not reducible. It has been published in Swedish during 2014, and hopefully eventually also in English.

OS5-5

Color Universes for the Chilean Heritage

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ABSTRACT

The Government of the Libertador's Region in Chile, south of the capital city of Santiago, decided to add value to its cultural heritage through the design of two new interpretation center buildings for the region.

The first will shelter the 11,000 year old archaeological and paleontological site in Tagua Tagua lagoon. In this site, bones of mastodons and other smaller mammals –including deer, horses, and rodents– have been found, as well as human remains belonging to an extinct culture. The second project is related to the work of the famous "chamanto" poncho weavers, high-quality and beautiful woven pieces that were granted the Award for Excellence by Unesco in 2011.

The architecture's office responsible for the projects entrusted a study on color for each center, including the development of color palettes for the design of the architecture, museography, and graphic art. A comprehensive color study was conducted in each site, including field visits, interviews, photographs, watercolor paintings, samplings and color surveying. The first project –the paleontological interpretation center– focused on the colors of the landscape, architecture, land and museum pieces, mainly bones and arrow tips. The second project –the Chamanto ponchos– focused on the colors of the landscape and the threads used by weavers.

Colors found were arranged into color universes specially created for each project. A color universe is a conceptual arrangement of colors related to its origin, ownership, culture, and space, among others. These universes were then used to design the colors of the architecture, museography, graphic art and merchandising in each project. The application of these color palettes to different supports, keeping a consistent project image, was a huge challenge.

We hereby present the full study, from the field visits to develop the color study and the collection methods used, to the creation of color universes and finally, the application to the project's global image, from the (indoor and outdoor) architecture to the museography and graphic design (papers, signs, etc.) and merchandising (T-shirts, bags, mugs, etc.).

OS6-1

Forsius' Second Colour Order Diagram of 1611 from the Iconic Point of View

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ABSTRACT

In her AIC 2009 paper the author demonstrated how important the cultural and historical context of colour order systems is for understanding them. This is especially the case for the colour order system of pastor, astronomer, mathematician, natural philosopher and astrologer Sigfrid Aron Forsius (ca. 1550–1624) that is illustrated by two diagrams in his Physics, or a Description of the Qualities and Properties of Natural Things of 1611. As the manuscript remained in the Archives of the Royal Library of Stockholm unpublished for more than 330 years until Johan Nordström published the transcription of the handwritten text in 1952, serious and critical debate of his work, and thus of his colour order diagrams, as well as its impact and acknowledgement previous to 1952 is non-existent. On the basis of printed evidence of his time, the author proved that Forsius' second diagram could perfectly be interpreted as a sphere, contradicting Kuehni and Schwarz's thesis (Colour Ordered, 2008) of a "linear" system. The present paper rejects Werner Spillmann's thesis (2001) that the colour order of Forsius' second diagram is incompatible with a sphere. The author bases her hypothesis on her own

observations of the armillary sphere at the Globe Museum of the Austrian National Library in Vienna which show that Forsius' second scheme can be interpreted as a colour sphere, long before Otto Runge's Farben-Kugel (Colour Sphere) of 1810. In the paper, these observations will be demonstrated with pictorial evidence.

Further, Forsius' diagrams are considered here in the context of contemporary colour theories such as those of François d'Aguilon (1566-1617), Athanasius Kircher (1602–1680) and Robert Fludd (1574–1637).

OS6-2

Five Colours - A Study of Chinese Traditional Colour

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ABSTRACT

This paper contains the research of Chinese traditional colors and the significance of the study. With the long Chinese history, color play an important role in terms of different aspects, e.g. in culture, literature, philosophy and politics and so on. However, the current research does not profoundly reflect that in either width or depth. The intention of the research is to uncover the meaning of Chinese traditional colors and conclude some theoretical contribution to the color knowledge in modern deign context.

After reviewing the way of naming the colors in Chinese ancient literature and documentation, there are three methods: 1. Abstract Name (used for Primary Colors) 2. Entity Name (used for Secondary Colors) 3. Abstract + Entity Name (used for Tertiary Colors). From the case study of the Japanese traditional color system, it shows that the Japanese used more of a precise way to name colors than Chinese's. Moreover, looking back to the early period of Chinese history. There are earliest colors are called Five Colors (五色), which are Red, Blue, Yellow, Black and White (赤，青，黄，黑，白). The names of Five Colors literately came from the description of life scenes through the study of oracle characters. It recorded the absolute characteristic of some proponent visuals. And all these memories strongly reflected certain events, activities or daily lives.

The Five Colors were used to represent the Wu Xing (五行) in color. It brings the concept of Five Colors into another level, which incurred more philosophical meanings. The metaphor of Five Elements enriched the imaginations of Five Colors. Wu Xing also known as Five Phases, which is a circuit by mutual generating/ overcoming each other. This typical movement or transition thinking provided a fresh viewing point with dynamic perspectives. Perhaps Chinese is the very first group of people who noticed the relationship between color and the environment. The essence of Wu Xing is the change and the colors changed by the circumstances as well.

The cognitive bias of the colors came from the abstract naming. There is no accurate term or parameter to quantize the volume of colors. As colors can evoke difference imaginations from different experiences, in this sense the way of interpretation of colors is similar to the images. Color always associated with imagery and it should be seen as scenery in the same way. This image of color somehow changes all the time. No color stays the same. The relationship of the color with the environment affected the colors consistently. In opposition, attribute of the colors subtly influenced people and environment from all the different aspects and perception. It inspires people to no long treat color as a cold number code but an emotional image with interactive stories behind.

OS6-3

Meeting New Challenges in Colour Tendencies in Norway

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ABSTRACT

A recent debate in the Norwegian press, and in part raised by the authors through the exhibition

Colour in the City Trondheim 2014, points to a dramatic change in the colour pallet used both in the repainting of existing buildings and as a dominant tendency in recent architecture. This is exemplified in a substantial shift towards an achromatic pallet. Jotun, the major provider of paint in Norway, has noted that 80% of the exterior paint sold in recent years has been white, grey, brown or black. This is counter to a long tradition of chromatic variation in both vernacular and 19th and 20th century architecture.

Colour and materiality play an essential role in shaping our perception of place and identity. Colour is information, it tells us about history, about status, about territories and functions. Previously distinct historically chromatic neighbourhoods are being eroded and new property developments built without any chromatic character or differentiation. Area character as distinct architectural styles and chromatic qualities is an important contribution to the identity and differentiation in the urban environment, it provides both a means of identification, navigational affordances and a generator of aesthetic atmospheres in the architectural gestalt. Place is more than a street number, it is an ensemble of qualities and relationships that make meaning; materiality and colour are a key component in this process. The scope of this paper will be an analysis of the drivers of this process from developer to the architect to the consumer with the intention of developing a colour program methodology that meets the pressures of increasing urban densification.

OS6-4

The Image of the Color Red in Letters: A Study Based on the Historical Backgrounds of Russia and Japan

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ABSTRACT

Color has been an important topic for thousands of years. In this presentation I will focus on the cultural meanings of colors, especially the use of the color red in letters. The purpose of the survey is to discover the differences in point of view about color between Russia and Japan and to examine the traditional meanings of red in the two countries. The key points covered are the historical significance that people have attributed to this color through the ages before modern times, and the magical use of letters from antiquity. Use of the color red was prevalent all over the world. The red pigments were used for paintings on walls in caves, for graves, and in many other ways. It is obvious that people had a common perception of this color. But history also gives cultural meanings to colors. How they were symbolized in the past and some historical images of colors still influence the image of the color red today. For example, nowadays in Russia, writing in red letters for celebrations is very common. Red is associated with happy occasions, and is considered the color of strength and of life force. In contrast, in Japan this color can have positive meanings, but sometimes it is the color of kegare, a traditional concept of defilement. It is taboo to use the color red for letters in Japan. In this presentation, I will consider these different interpretations of the color red. There are cultural studies that focus on the history of colors (by Pastoureau, 2013; Tokui, 2006; Ito et al., 2005), but here I will emphasize the use of colors in letters, which are imbued with a magical quality. This study is related not only to our lifestyles today, but to the cultural history of etiquette and manners in Russia and Japan.

OS6-5

Japanese Color Names Reflecting Dyeing: With a Focus on Their Color Terms in Brown Regions Including More than 100 Browns

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ABSTRACT

The word brown seems to be derived from “burn” through a process called metathesis. Through this process the “u” and “r” in “burn” switched positions to “brun” (OE. brūn), which later came to be pronounced and spelled as the “brown” we now know, through a process called the Great Vowel Shift and French influence. Brown includes colors ranging from yellow to near black, which comes from the color appearing after something on fire has started to burn with less intensity. In Japan brown has been called *cha-iro* (茶色), meaning the color of tea used for dyeing, since the Muromachi period (A.D. 1338-1573). During the Edo period (A.D. 1603-1868) the most popular color was *cha-iro* (brown), and the second most popular was mouse color (gray). There was a phrase, *shijyuu-hachi-cha, hyaku-nezu* (四十八茶百鼠) meaning ‘forty-eight browns, one hundred mouse colors’, for a variety of color terms. The number of browns is not actually forty-eight, and has been left unexplored. Here we will show there are, in fact, over one hundred browns.

The Edo Period government established the “Sumptuary Regulation”, preventing commoners from living a life of luxury. By decree of this law, all people regardless of status were prohibited from wearing luxurious kimono. Because of this, bright and flashy colors could not be used in *kimono*, and only the use of subdued colors such as browns or grays (mouse colors) was permitted. Nevertheless, the people of the Edo Period naturally wanted to enjoy fashionable refinement, so they took these simple colors and wove them into countless variations.

These traditional colors of Japan have been handed down to modern times, showing the Japanese sense of beauty and wisdom. *Kobicha* (媚茶) is one example of the “forty-eight browns”, suggesting a sensuous or coquettish quality. The color name is derived from *kobucha*, or kelp brown, and also comes from the verb *kobiru*, which means to butter or sweeten someone up by fawning on them. This color would have been the natural choice for a person of the time to wear if they wanted to get into someone’s good graces. *Rikyucha* (利休茶) was a color loved by the tea master Sen-no-Rikyu in the Momoyama Period (A.D. 1573-1603). *Baikocha* (梅幸茶) was a greenish-brown color loved by Onoe Kikugoro. Before he came to be called Kikugoro, this famous *kabuki* actor was named *Baiko*, hence the color name. These all reflect a preference in Japanese culture for wordplay and euphemism.

Japanese color terms emphasize the notion of a sense of the season, casualness (naturalness, i.e. a color tone that is subdued), and the beauty of a moment.

OS7-1

Assessing Glare Using LED Sources Having Different Uniformity Patterns

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ABSTRACT

LED (light-emitting diode) lighting source has become the most important clean source because of its special properties such as energy-saving and long service life. However, due to its small size, glare has become a serious in LED lighting design because it can cause safety accidents and visual impairment. In fact, there have been many methods to evaluate the glare produced by traditional lighting source, but for LED source, the existing standards may not be suitable because of its high luminance intensity, small size and non-uniform distribution.

In this work, an experiment was designed to investigate the indoor discomfort glare. Experimental apparatus was designed to consider a wide range of glaring conditions. The physical parameters included luminance intensity, the size of LED matrix, the pattern of LED luminance distribution, the background luminance, and the viewing angle. Overall, there are 108 different lighting conditions in this experiment assessed by 20 observers, each one did twice. In each lighting condition, 20 observers visually assessed the glare. In total, 2160 estimations were made.

The data were analyzed and the results showed that the five parameters all had statistic significant relations with human sensation of glare. LED with larger luminance could produce more

glare if other conditions are in the same level. Also glare increases with the decrease of LED matrix's size and viewing angle. As for the background luminance, it was found that it is obviously feel the discomfort glare in dark background. For different patterns, discomfort glare increases with the increase of contrast between luminance from the boundary LEDs and inner part of luminance. In other words, the greater non-uniformity, the more discomfort glare. Finally, we compare the visual glare with those predicted by different models including UGR, VCP, UGR for small sources, BGI and DGR. The results also showed that UGR, UGR for small sources and BGI models are reasonably predicted for LED discomfort glare to some extent. However, we also demonstrated that there are rooms to improve to consider the irregularity of the model.

OS7-2

Evaluation of the Performance of Different Colour Rendering Indices Employed in LEDs

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ABSTRACT

CIE-Ra, the colour rendering index (CRI) proposed by the International Commission on Illumination (CIE), has been used as the criterion to evaluate the colour rendering properties of a light source since 1974. However, recent studies have shown that perceived colour qualities of newer LED light sources are not well predicted by CIE-Ra. Various CRIs have been developed, which all claim that they perform better than CIE-Ra. The aim of this research is to evaluate the performance of different uniform colour spaces (UCSs) and available CRIs.

With this in mind, a psychophysical experiment was carried out. Nine pairs of light sources were prepared, each including a reference and a test light source at three correlated colour temperatures (CCTs), 2850K, 4000K and 6500K. All the reference sources with high CIE-Ra (>90) were produced by a 16-channel LED luminaire, while the test sources included two categories: conventional sources such as an incandescent lamp (2850K), fluorescent lamps (4000K and 6500K), and LED sources with different CIE-Ra levels (~85, ~65)in a self-built LED viewing cabinet.

A pilot experiment was first conducted to match the grey background in the reference viewing cabinet and that in the test viewing cabinet. Comparing the measured data of the two backgrounds and visual condition, it was confirmed that the results from the CIE 1964 standard colorimetric observer performed better than those from the CIE 1931 one.

Thirty samples were selected based on various existing colour rendering sample sets such as those used by CIE-Ra, CQS and CRI2012. They had a good coverage in CIELAB colour space. Each sample had a field size of 5 degrees, i.e. sample size of 7.5 cm by 5 cm at a viewing distance of 50 cm.

Ten observers participated in the main experiment. They were asked to view the two identical samples presented under the test and the reference light source in two viewing cabinets, respectively. Each observer was asked to assess the colour difference of the pair of samples, according to a grey scale. Percentages of individual colour difference components (lightness, chroma and hue) were also estimated. For each pair of light sources, four samples were assessed twice by each observer to investigate the observers' repeatability. Therefore, in total, 12,240 assessments were accumulated (4 questions × 34 samples × 9 test sources ×10 observers).

The results were used to test different UCSs including CIELAB, CIELUV, CIEU*V*W*, and CAM02-UCS, respectively. The calculated colour differences were compared to the visual colour differences under the sources studied. The results showed that CAM02-UCS gave the consistently best performance among all UCSs.

Different CRIs were also tested using the present data, including CIE-Ra, CQS, CRI-CAM02UCS, and CRI2012. It was found that all CRIs gave similar performance and CQS marginally outperformed the others using the average colour difference in each pair of light sources. However, CRI2012, which is based on CAM02-UCS colour space, worked best on evaluating colour fidelity of

light sources comparing with individual predicted colour rendering and perceived colour difference values. Also, all colour fidelity based models performed better than those colour preference models such as FCI, MCRI, colour gamut index.

OS7-3

A Study on the Lighting of Bathroom for the Elderly

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ABSTRACT

A bathroom is a space where a physiological need is satisfied, and at the same time health care and recreation are ensured. Even though it is relatively small compared to other spaces, various actions are carried out in this space. Therefore, it needs sanitary and functional lighting. Because most bathrooms are closed without any windows, the role of lighting is very important. In particular, a bathroom is a space where the accident of the elderly is most frequently reported. Because old people's activities of daily living are closely related with their health conditions and poor vision, it is required to design lighting ion consideration of the characteristics of the elderly's vision. In most apartment buildings, recently, ceiling-recessed direct lighting has been installed in a bathroom. As LED lamp is being used for indoor lighting, there should be a study on its use in a bathroom. Therefore, this study has investigated optimum illuminance and color temperature ranges for the elderly aged 65 or older against bathrooms where ceiling-mounted direct LED lighting was installed. For this, a total of 15 testees (65 to under 86, 75 years old in average) were examined. In terms of color temperature, 3,000K, 4,000K, 5,000K and 6,000K were used while illuminance was divided into the following six categories: 100 lx, 200 lx, 300 lx, 400 lx, 500 lx and 600 lx. The testees are asked about the brightness of a bathroom (3,000 (L) x 2,000 (W) x 2,000 (H)) and their preferred level and wrote their answers on the sheet. The test results were analyzed through descriptive statistics, significant difference test and multiple regression analysis. In addition, the study results were compared to the previous studies which derived optimum illuminance and color temperature ranges for young adults in their 20-30s.

OS7-4

Sitting Posture Based Lighting System to Enhance the Desired Mood

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ABSTRACT

In this study we propose a posture-based lighting system focusing on office environment. Since one's posture is a cue for desired mood, we intended to develop a posture based interface that controls the quality of lighting. As previous studies have revealed there are optimal combinations of illumination and correlated color temperature that can enhance the affective experience of the human.

In the empirical study, we set up an office environment and observed people's postures while they were in various affective states. In order to figure out the sitting postures, we attached six pressure sensors and one distance sensor on an office chair. From the sensors we received the signals and then transformed them into manageable data through Arduino Processing. A total of 10 college students were recruited, and the experiment was comprised of two parts. In part 1, we recorded people's postures during they were participating in the following four tasks: (1) memorizing words, (2) playing Tetris, (3) reading magazine articles, and (4) taking a rest. Each of these four tasks acquired 10 minutes to complete and was targeted to a different affective. In part 1, people were not informed that their sitting posture was being recorded. On contrary, in part 2, we explicitly asked people to take a posture that best fits to the given tasks.

From the empirical study, we clustered nine sitting postures based on five sets of data, such as the pressure of head, lumbar, hip, thigh, and the backrest-body distance. The characteristics of a sitting posture were highly dominated by the lumbar pressure as well as the backrest-body. For example,

for the task (1), the lumbar pressure decreased, while the distance between the backrest and body increased. This indicates that people are subconsciously leaning forward when working intensively, whereas leaning back when taking a rest. In addition, differently from our anticipation, the difference between the subconscious postures in part 1 and conscious postures in part 2 did not show a statistical significance at an alpha level of 0.05. Therefore, we averaged the posture data from both parts when we matched the nine sitting postures into the four task types.

Finally we developed a posture based lighting system that manipulates the quality of an office lighting operated by the change of one's posture. Facilitated by the system, the illumination varies between 300 and 900 lx, and the correlated color temperature ranges between 3500 K and 7000 K. This study demonstrates how the human behavior can interact with the lighting mediated through emotion.

OS7-5

Colour Lighting Based on Chromatic Strength

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ABSTRACT

Emergence of full-colour LED lighting has increased opportunities to illuminate towers, bridges, monuments, etc. with vivid coloured lights. In its technical report CIE 94: Guide for Floodlighting, the International Commission on Illumination (CIE) defines the recommended luminance for illuminating an object with white-colour light such as mercury lamp and high-pressure sodium lamp as 4 cd/m^2 (poorly lit zones), 6 cd/m^2 (average zones) and 12 cd/m^2 (brightly lit zones) according to the luminance of the surroundings. However, it does not define recommended illuminance and luminance for illuminating the object with coloured lights. As a result, it is impossible to easily calculate the quantity of light required for giving the suitable appearance.

Accordingly, we conducted a matching experiment on the object illuminated with white-colour light and the object illuminated with coloured lights, for finding the luminance ratios when the both objects are perceived as having equal strength, and derived recommended luminance for colour lighting. Specifically, we presented a stimulus using white-colour light (to be referred to as the white-colour stimulus) and that using coloured lights (to be referred to as the chromatic stimulus) to the subject. The subject was allowed to freely adjust the luminance L_C of the chromatic stimulus with a dimmer at hand until he or she perceives as the strength equal to the white-colour stimulus of luminance L_W. We instructed to the subjects that the strength was a "concept combining brightness and conspicuousness." After matching was completed, we measured the luminance L_C of the chromatic stimulus and presented a different chromatic stimulus to make matching. As a result, we found that the recommended luminance L_C for colour lighting can be expressed by a variable differing depending on the *u'v'* chromaticity of the illuminated object.

In addition, we conducted a verification experiment to confirm whether derived recommended luminance is utilized for actual lighting design. In detail, we conducted an experiment to confirm whether the object is equally conspicuous when the object is illuminated with different coloured lights to the identical strength. We verified that the recommended luminance for colour lighting can be utilized for actual lighting design.

OS8-1

Influences to Color Constancy by Wearing the Optical Dichromatic Filter or the Aged Lens Filter under Static and Rapidly-changed Colored Illuminations.

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ABSTRACT

Human beings have an ability to estimate an original color of an object regardless of color of a illumination, that is called as color constancy. The color constancy also exists on red-green color deficient observers (ex. Ma et al., AIC2012). There are many arguments about mechanisms of color constancy and it has not been confirmed yet. Thus, in the process of investigating the mechanism, we tried to evaluate effects to color constancy by innate adaptation and learning in color deficiency and by the long-term adaptation in aging. This evaluation could be made by measurement of the color constancy on a color normal observer wearing the functional filters. One filter was the optical dichromatic filter, "Variantor (by Itoh Optical Industrial Co.)," which is the functional spectral filter simulating the color discrimination of dichromats for color normal observer. The other filter was the aged lens filter, "Simulation Filters of an Aged Human Lens (by Geomatec Co.)," simulating the age-related ocular lens density of 75 years old person for 32 years old observer. The color normal observer wearing one of these filters would have pseudo-perception of dichromats or elder person, but he or she could not have the innate or long-term adaptation and learning. We additionally used the rapidly-changed colored illumination which changes illumination color in every 5 seconds in the order of Red-White-Blue-White- (or reversal order). Under this rapidly-changed colored illumination, we expected that the short-term adaptation (von Kries type of adaptation) in the possible mechanism of color constancy, especially at retina, would be minimized. Overall, we expected that the experimental condition of this research would be the extreme case distorting the color constancy effect. By these reasons, this study would have the other purpose that we would be able to estimate the maximum difference of color constancy between dichromats, elderly people and young color-normal observers.

In this study we performed two experiments. In Experiment 1, we performed categorical color naming by 11 basic colors (white, black, red, green, yellow, blue, brown, orange, purple, peach, ash) for Optical Society of America Uniform Color Scales (558 chips) under one of illuminations; bright white (223 cd/m^2 on a standard white plate placed at a color chip stand), (dark) white, red and blue (about 17.5 cd/m^2) lights. The categorical color naming was made four times on one chip under one of three states; wearing no filter, the dichromatic filter, or the aged lens filter. In Experiment 2, we used 134 chips (at L=0 and L=1) of OSA Uniform Color Scales under the rapidly-changed colored illuminations at 5 seconds interval and other conditions were identical with Experiment 1.

In Experiment 1, under the condition of wearing the dichromatic filter, we observed typical changes in the result of the categorical color namings that can be predicted by effects of the dichromat filter under each illuminant's colors and it means that we could not find any distortion of color constancy. Additionally, we found that almost no change in color constancy by wearing the aged lens filter, in the measurement by the categorical color naming. In Experiment 2, the result was almost the same with the result of Experiment 1. The accuracy of color constancy became worse, but the tendency of color namings was almost the same between static and rapidly-changed colored illuminations. The results of this study indicate that the color constancy, at least as long as measured by the categorical color naming, is robust against the change of spectral distribution of reflected lights from objects by filters and rapid change of illumination color. It supports that color constancy strongly reflects the higher-order brain processing like estimation of illumination, rather than the simple short-term adaptation effect at retina.

OS8-2

Spectral Functional Filters for Optical Simulation of Dichromats in Color Discrimination

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ABSTRACT

Dichromats do not congenitally have one type of cones and color discrimination using that cone is theoretically impossible. Protanope and deuteranope do not have functioning L- and M-cones at retina and additionally, it has been thought that they have no Red-Green opponency. Although there are some arguments of color perception of dichromats, especially about perception of red and green,

it has been well accepted that dichromats cannot discriminate colors on confusion lines in chromatic coordinates.

For dichromats, we should not use combinations of colors on such confusion lines for signs, indications, textbooks and other important notices. This concept was called as Color Universal Design. However, in many cases, it was not practical to measure all colors by a colorimeter, mostly because designers in color normal initially could not recognize problems in some color combinations. It was more practical to take digital pictures of scenes and to present them in modified colors converted by special software. We though that if we would make the spectral functional filter to check the color combinations for dichromats, it would be more flexible, faster and easier to find initially-unexpected problems in color combinations.

Cone sensitivities of L- and M-cones, however, mostly overlap, and it was not possible to eliminate the stimulation of one type of cones by a spectral filter. Instead, we tried to simulate the ability of color discrimination defined by CLELAB color difference. Firstly, we defined the color set for evaluation. We used 5745 modeled Munsell color chips under D65 illumination. The modeled reflectance of each Munsell chip consisted of the offset reflectance function (as the average of 1239 Munsell chips) and three fundamental reflectance functions (obtained by principle component analysis) multiplied by three independent parameters for each chip. Here, we set the luminance factor Y to make Y/Y_o equaled 0.1, meaning that Munsell Value was approximately 3.8. The color difference was defined between each Munsell chip and the neutral chip (N/3.8). In the next step, we assumed the spectrally band-pass filter which has two square-wave-shape peaks and three bottoms in its transmittance defined with 9 parameters. Filter effects were simply obtained by using the filter transmittance. To simulate dichromat's color discimination, from the spectral reflectance, we calculated each Munsell chip's XYZ tri-stimulus values and obtained LMS cone stimulations by Smith-Pokony cone fundamentals. We used the assumption that L- and M-cone stimulations always equal zero for protanope and deuteranope, respectively. Then, the tri-stimulus values were reversely calculated from LMS stimulations and used for color difference calculation. Finally, we compared the CIELAB color differences between modeled protanope and deuteranope and each filter. The best filter was selected to minimize the "error" by changing 9 filter parameters under Genetic Algorithm.

We successfully have made three kinds of the dichromatic filters even for commercial products ("Variantor" by Itoh Optical Industrial Co.); universal type, protan (P) type and deutan (D) type. The universal type of the filter was designed to select worse case between P- and D-types in terms of color discrimination. These filters were evaluated by Ishihara-plate, Standard Pseudoisochromatic Plates (SPP), D-15 and 100-hue test. As planned, results of SPP and 100-hue tests indicated that color normal observers wearing P- and D-types filters were evaluated as protanope and deuteranope, respectively. The results with the universal filter indicated mixture and/or middle of protanope and deuteranope.

OS8-3

What are Memory Colors for Color Deficient Persons ?

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ABSTRACT

Color-deficient persons are unable to discriminate some specific colors and hence are having great difficulties in their lives [1]. R. C. Baraas et. al. studied the degrees of color constancy in subjects with congenital red-green color deficiency [2]. However, the mechanism of memory color for color vision defect is less clear until now. We hope to build up friendly lighting environment for people with color vision deficiency (CVD) by means of investigating memory colors for color-deficient persons. After conducting the visual assessment experiment, we could realize what are perceived colors on the familiar objects for people with color vision deficiency, then buildup the database of memory color for color-deficient persons.

A well-calibrated monitor was used in this study, and the visual assessment experiment was conducted in a dark room. Total 14 kinds of test images used in the experiment include the following

familiar objects with main colors or various rendered colors: apples (green, red and yellow), lemons (yellow and green), banana (yellow), orange (orange), tomato (red), leaf (green), sky (blue), strawberry (red), woman face (skin color) and cauliflower (milk white).

The evaluated data was analyzed by bivariate Gaussian function [3]. The evaluation examples of "banana" image for CVDs which include (a) normal color vision, (b) Protan CVD, (c) mild deutan CVD and (d) strong deutan CVD. These examples of banana memory color show that; the high memorized area of normal color vision forms a circle on u'v' diagram, however the results of CVD would form different degrees of memory-color ellipses. By analyzing the colorimetric results of memory color plots; we could determine the type and severity of CVD for a subject according to the distribution of his/her memory-color ellipses. This study could help us realize more about color vision system of CVD. We hope this result is beneficial to CVD research.

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OS8-4

Establishment of a Model Colour Palette for Colour Universal Design

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ABSTRACT

Color Universal Design (CUD) is a user-oriented design system to allow information to be accurately conveyed to people with diverse types of color vision. Because of genetic variations or eye diseases, some people cannot easily distinguish certain combinations of colors. However, it is not practical to avoid all such combinations when painting graphic objects that require multiple colors, such as public signs, graphs and drawings, maps, and web pages. An alternative approach is to adjust the hew, saturation, or brightness of each color to maximize mutual separation. For example, red-green colorblind people can actually distinguish the two colors if red is slightly yellowish and green is bluish. Although this is a potentially promising way to provide information in many colors while keeping accessibility to diverse people, fine-tuning of color tones is not easy for designers who usually have only limited knowledge about the characteristics of various color vision types.

To address this issue, we formed a collaborative project between research institutes, leading companies in the paint and printing-ink industry, and NPO of colorblind people that advises CUD, to establish a palette of least confusing colors with precisely defined color values. We first asked people with common-type (normal) color vision to classify several thousands of color chips into groups of color categories. We then asked colorblind people to examine the color chips in each category and discard those that appear confusing. We then asked colorblind people and low-vision people to examine the remaining chips to select the color in each category that are most distinguishable from the colors of all other categories.

Through such screening, we obtained a set of 20 colors: nine vivid colors that are suitable for small objects, seven relatively pale colors for painting large objects and backgrounds, and four shades of achromatic colors that are least confusing with chromatic ones. Considering that colored information in real life is mostly presented in three major ways - painting, process color printing, and computer/mobile screens - we fine-tuned colors of specially-made paint samples, proof prints, and patches displayed on calibrated computer monitors, to make suggested color definitions in Munsel values, CMYK values with industry-standard profiles, and RGB values in sRGB color space.

The resulting palette provides for the first time a systematic way for conveying colored information that is (A) least confusing for people with diverse color vision types and (B) consistent across different media. The palette is already being used in a wide variety of products including train line maps, signs in the public space, drawings in the school textbooks, as well as graphic interface of electronic devices.

OS8-5

Color Universal Design

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ABSTRACT

The objective of this work is the Color Universal Design available to all people who have different kinds of color vision from each other.

Most people can see six or seven colors in a rainbow, and few people can see less than three. Those who can see less than three are known as ‘red-green confusion’ people.

We have produced the concept of Color Universal Design Organization, CUDO, in Japan since 2004. The social aim of the organization is to improve the comprehension of people who have various kinds of color vision of their environment, for example, when searching for information from a public transport map. CUDO is organized into groups of with persons 3 types of color vision. We call these P-type, protans and protanopes, and D-type, deutans and deutarnopes, and C-type, common type trichromatic. We plan to consider encompasses red-green confusion people still popularly negatively known as being ’color blindness’ and people with ’normal’ color vision. It is important to use words which are not part of the negative lexicon regarding people who do not have full color vision.

As human color vision encompasses the various hybrid types of L-cone and M-cone, C-type is therefore not normal and P-type and D-type are not ’color blindness’. In today’s, urban environment we see many colors, and multicolored letters on a great variety of background colors, colored maps and color signs.

In this research, we looked for kinds of red, blue, yellow and green that P-type, D-type and C-type do not confuse with each other. ’Red-green confusion’ people do not confuse all kinds of red and all kinds of green. From their own experiences they observed when they were confusing colors. Some P -type and D-type people who consciously monitored their color vision knew their confusion category color.

We investigated color visual communication between people who have different color vision.

As P-types see red-color darkness, we selected a kind of vermillion. The selection of a kind of green that all color vision types can discriminate from other colors was difficult work because D-types frequently recognize bluish-green and gray as being in the same category. Ultimately, these kinds of red and green were selected with in a very narrow range.

What we propose is a new, universally color system which facilitates for visual communication for both P, D and C-type people.

These are 4 colors where the same information can be seen correctly by a person of any color vision type.

OS9-1

An Investigation of the Appearance Harmony using Real Materials and Displayed Images

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ABSTRACT

Color harmony has long been of interest to researchers in different fields who design the colors

of various objects. When sensing harmony among actual objects, not only the harmony among the colors but also the appearance of harmony of the materials is an important consideration. Although the appearance of harmony in relation to specific materials has been investigated, harmony among different materials has not received adequate attention. In our previous study (Tanaka et. al., AIC2014), we investigated the appearance of harmony for various materials by conducting psychophysical experiments to collect quantitative data. In the experiments, we prepared 30 samples made from the following actual materials: fabric, paper, stone, wood, leather, metal, plastic, glass, rubber, and ceramic. In order to help subjects distinguish color harmony, we provided samples with a grayish color except for the brownish-colored wood materials. In different two experiments, subjects were/were not allowed to tilt the sample pairs to provide a comprehensive judgment of harmony. The results indicated that the sample pairs with similar texture patterns were viewed as harmonious, even though their materials were different. Furthermore, the appearance of harmony of the materials was significantly affected by the subjects' reactions to the reflections of the tilting samples. In this study, we further investigate the appearance harmony using real materials and rendered images based on a psychophysical experiment. In the experiment, we prepared rendered 435 round-robin pairs by capturing the material samples set up in a viewing booth a Canon EOS 5D Mark II with a sRAW2. For the output monitor, we used an Apple 15.4" MacBook Pro with Retina display. The widescreen, LED-backlit IPS screen has a glossy finish and a native resolution of 2880 × 1880 pixels with 220 pixels per inch. We asked to five participants to evaluate the harmony of rendered materials rating in 10-point scale to rate harmony-disharmony. Then, we compared the score for rendered images and one for static actual objects derived from our previous study. Our results indicated that the appearance harmony of some materials was significantly affected by the subjects' reactions to the visual information of the samples with/without monitor. The findings from the PCA analysis indicate that harmony of categories of glossy or transparency materials are more likely to change, when the materials are displayed as images. These results suggest that appearance harmony should be studied after having considered much difference between the displayed images and the actual samples.

OS9-2

The Colour of Gold

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ABSTRACT

There is nothing absolute about the colour of an object surface: it changes continually with illumination and orientation. So how can we define the colour of a surface? Given many images of the same object, even under the same light from many angles, what is the 'true' surface colour? Colorimetry specifies the colour of an object as the product of the illuminating power by the reflectance factor of the surface by the sensitivity of the observer, integrated over all wavelengths of the visible spectrum. This is the basis of the ubiquitous CIE system, but it relies on the assumption that the surface is perfectly matte so every point reflects the incident light equally in all directions, i.e. that it is perfectly Lambertian.

In fact almost every real material exhibits some angular dependence in the way it reflects light, and this must be taken into account when modelling the appearance of the object in the scene, by adding a gloss component to the underlying diffuse colour. The added light may appear as a sheen over the surface or as localised specular highlights, but its effect is to modulate the lightness and thereby change the colour stimulus. This is especially true of gold, which combines glitter, specularity and sheen over a wide range of angles to give it a uniquely lustrous quality that sets it apart from ordinary materials. To specify the colour of gold only by a single colorimetric triplet is dull indeed.

The dome imaging system at UCL enables sets of images of an object to be taken with illumination from different directions. A hemisphere of 1 metre diameter is fitted with 64 flash lights, calibrated so that the geometric centroid of every light source is known to within 3mm. A Nikon digital camera at the 'north pole' captures a series of 64 colour images, each illuminated by light from a different direction, all in pixel register. This enables the object to be visualised from a fixed viewing angle, i.e. vertically from above, for many different angles of incidence.

The paper will explain how the surface normals are calculated from regression over a subset

of the intensity values. The colour albedo arising from this procedure is a good approximation of the intrinsic diffuse component of the surface reflectance. The specular component of reflectance is then modelled as a radial function based on the Lorentzian, with four parameters controlling the shape of the flank and peak. The BRDF of a homogeneous region of the object surface can be derived by aggregating and fitting the distributions over many pixels centred on the specular angle. It is shown how for gold this conforms to the Shafer dichromatic model of reflectance.

The images reconstructed from this model are virtually indistinguishable from the original photographs taken in the dome with light at the same incident angle. Examples of several golden objects will be given, including a scarab with a gold band from ancient Egypt (c. 1500 BC).

OS9-3

Preferred LED Lighting for Wood Surfaces and Colored Surfaces

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ABSTRACT

The perceived atmosphere of an interior space is a whole of all consisting elements. Light as part of this constructed environment influences specifically the visual appearance of interior elements, like objects or materials. In a previous study preferences for 20 interior materials under different light situations were evaluated. In this study appearance of 8 different types of wood and 12 color samples from the Natural Color System (NCS) catalog were examined. This were 4 highly saturated colors in unique hues and 4 saturated colors in hues exactly positioned in between. The latter mentioned hues were additionally presented in pastel versions.

As explained before the illumination of the scene contributes to its visual appearance. The present research featured a side by side comparison of two scenes illuminated with different LED light sources: warm light with a Correlated Color Temperature (CCT) of approx. 3000K or cold light with a CCT of approx. 4000K. For both sources the Color Rendering Index was above 95. The average Illumination Level was in both scenes 1400 Lux.

By performing a forced choice task participants expressed their preference for one out of two light conditions. The study design was within-persons (all participants were confronted with all experimental conditions). Twenty-seven second year interior architecture students participated in the experiment as part of their study course.

The results of this explorative study were not fully conclusive. For red color the results from the previous study were confirmed. Preferences for other materials did not differ significantly from the chance level. Hence the results of this study lead to the assumption that light temperature might be a decisive factor in lighting choice for specific materials. It might not be the case for all materials, but certainly there are colors, probably also types of materials, that people have clear preferences for cold versus warm light.

OS9-4

Development of a Facial Imaging System and New Quantitative Evaluation Method for Pigmented Spots

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ABSTRACT

Quantitative evaluation for skin color and skin chromophores distribution is important in dermatology, physiology, pharmacology and cosmetic science. Various methods to evaluate facial pigmentation using image analysis have been proposed. They provides the visual information of melanin distribution. However, the current methods cannot provide quantitative information on

pigmented spots such as variation in size, shade of color and distribution pattern. In this study, we describe our facial imaging system and pigment-specific image-processing techniques, and we also propose an image evaluation method focusing on the analysis of individual pigmented spot on wide area of a face.

Firstly, a facial imaging system which equipped with an illumination unit and a high-resolution digital camera was developed. The illumination unit employed fluorescent lamps as a light source. It was designed to provide diffuse illumination over a wide area of a subject's face to eliminate shadows and artifacts from specular reflections. Facial images were captured and were converted to *XYZ* values from RGB values based on a calibration using 100 skin color chips. Next, to determine the melanin and hemoglobin concentration, we established pigment-specific image-processing techniques based on coefficient between *XYZ* values and skin chromophore concentration. The skin chromophore concentration were calculated by a multiple regression analysis, assuming that the absorbance spectrum was linear sum of the absorbance spectra of melanin, oxygenated hemoglobin and deoxygenated hemoglobin. Finally, to obtain the features of individual pigmented spots within a cheek image, we established a simple object-counting algorithm to calculate their sizes, and the melanin concentration and so on. To validate the accuracy of quantitative image analysis, cheek images were captured using the facial imaging system and were compared with the measurement values using a spectrophotometer. Applying the new methodology for skin chromophore and individual pigmented spots to cheek skin images, we investigated the relationship between the characteristics of spots occurrence and age.

As a result of cheek image analysis with 200 Asian women, we confirmed that our illumination unit was able to measure skin color on wide area of the face accurately. In addition, a characteristics of age-related changes of pigmented spots was clearly demonstrated. In conclusion, our techniques for skin chromophores and individual pigmented spots allow us not only to provide the visual information of the melanin distribution but also to understand the characteristics of various pigmented spots in a face.

OS10-1

Colour Preference and Harmony for Athletic Shoe Designs

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AB3STRACT

Colour preference and harmony have both been concidered the most essential factors in the design of colour combinations. The relationship between these two attributes of colour has been extensively studied. For example, Schloss and Pamer recently found that colour preference and harmony both tended to increase as hue similarity increases, while preference relies more strongly on component color preference and lightness contrast. Nevertheless, most existing studies of colour preference and harmony, including Schloss and Palmer's research as mentioned above, have used abstract, contextless colour patches as the stimuli in the experiments. It is still unclear whether the results can also apply to real-world product designs.

To address this issue, athletic shoes, a product commonly seen and used in our every-day activities, were taken as an example in our study of colour preference and harmony. To achieve this aim, a psychophysical experiment was carried out using 404 recoloured images of athletic shoes as the stimuli, presented on a calibrated computer display situated in a darkened room. The 404 images were generated from two original shoe images, one from Nike and the other from Adidas, each manipulated by varying the two-colour combinations of the shoe design, including the main colour of the shoe and the logo colour (i.e. the Nike tick and the Adidas stripes). Each of the two original shoe images were recoloured using 202 colour combinations, consisting of 152 pairs selected from CIELAB space to cover a wide variety of hue, lightness and chroma, and 50 colour pairs selected from real athletic shoes currently available on the market. Twenty observers with normal colour vision, including 10 males and 10 females, participated in the visual assessment. Each observer was asked to rate each shoe images using two 6-step semantic scales, like/dislike and harmonious/disharmonious, as measures of colour preference and colour harmony, respectively.

The experimental results show that the color preference rating relied strongly on the main color

of the shoe regardless of the logo colour, while the color harmony rating was affected not only by hue similarity but also lightness difference between the main color and the logo colour. The results also show that shoe colors preferred by female observers tended to be liked by male observers, while shoe colors preferred by male observers were not necessarily liked by female observers. Regarding colour harmony, male and female observers both rated shoes with small hue difference as highly harmonious. The results also show high correlation between male and female data in terms of colour harmony, with a correlation coefficient of 0.83. For colour preference, however, the two gender groups had a correlation coefficient of 0.64, indicating a larger gender difference in colour preference than in colour harmony. These results can help refine and clarify existing theories of colour preference and harmony based on contextless colour patches.

OS10-2

A Study on Silver Metallic Color Preference - A Comparison of Responses by Age and Gender in Thailand -

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ABSTRACT

We have researched the designing conditions for more attractive color of the industrial products. It is significant for us to understand the customers' visual preference for each product in each nation. In this paper, we will show you the relationship between the surface colors of the silver metallic products and the customer's desired feelings such as the feeling of "high-quality". Especially we will report the comparative results of observation by age and gender in Thailand.

The questionnaire in Thai and English on the website was used for this survey. Computer graphics were used to represent the metallic surface products such as a laptop computer and a digital camera. Those have a slightly difference silver colors: reddish, yellowish, greenish and so forth. Each of color was controlled in ten hues of the Munsell color system. Five feelings as our target were set: "clean / pure", "relaxing", "high-quality", "stylish", and "favorite", which were chosen as the most important feelings for the metallic surface by Japanese customers. The respondents answered which color that they felt was the most "high-quality", for example. We have set seven target products: a fridge, a television, a smart phone and so on. More than two hundred persons in Thailand have cooperated with us in a wide range of age groups. We have compared the data according to age groups and gender.

As the result of the survey, we could find out some of the interesting tendencies. For example, we found that most young people under forties preferred bluish silver for the feeling of "clean / pure" in every product, in contrast, many elderly people preferred yellowish silver, especially in the personal mobile products: a laptop computer, a camera, a smart phone, and a music player. Elderly people also had the different tendencies depending on products for other four feelings. As everyone knows, color appearance of an elderly person is different from a young person by aging process of the lens. We need to confirm whether the above results of our survey were caused by the difference of color appearance. On the other hand, many female selected Munsell BP for the feeling of "clean / pure", "stylish", and "favorite". But otherwise we couldn't confirm a big difference between male and female.

Our investigation is still inadequate in number of respondents, especially for people aged over forty. We will continue to collect more respondents and observe the data again.

OS10-3

Effects on Impression of Taste in Color Stimuli

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ABSTRACT

Previous studies have already reported that colors affect the impression of taste to humans. However, it is not clear how the three attributes of color – hue, lightness and chroma have an effect on the impression of the five basic tastes – sweetness, bitterness, sourness, saltiness and umami, from the point of view in the quantitative measurement. Also there are some literatures suggesting a connection, that colors for use in the food package enhance the willingness to buy a product when they are the impression close to actual food taste, then pass along information to become the criteria of judgment for buying. So it seems to be the importance of investigating to the three attributes of color quantitatively. The purpose of this study is to examine the effect on impression of taste by color stimuli from the aspect of the three attributes of color.

Ten hues of the chromatic color (5R, 5YR, 5Y, 5GY, 5G, 5BG, 5B, 5PB, 5P, 5RP) and five of the achromatic color (N1, N3, N5, N7, N9) on the hue circle of Munsell color system were selected as the color stimuli in this experiment. In each hue of chromatic color, twenty-five stimuli were regularly chosen with the values of Munsell Value and Chroma in Munsell notation. Thus, there were around 255 stimuli in total. The stimuli were presented by 24-inch display placed in front of the observer and the viewing distance was 500 mm. They were displayed into the square at a visual angle of 15 deg in the center of the screen, and set N5 as the background color. Referring to the values of tristimuls values (*XYZ*) of Munsell color in JIS Z8721 with D_{65} light source, those colors were made. The observers were asked to evaluate the impression of basic tastes in stimuli presented, to each taste on a five-point scale (1: feel hardly, 2: feel slightly, 3: feel somewhat, 4: feel, 5: feel very much). The stimuli were presented randomly and the duration time was left to observer's discretion. The gray image of N5 was displayed as the inter-stimulus stimulus to remove the effect of the previous stimulus. The experimental booth was covered with a black curtain. It was illuminated by the D_{65} fluorescent lamps and the illumination of screen in the display was around 330 lx.

In the results, the impression given by color stimuli for the five basic tastes is almost agreed with the previous studies. It will be discussed the relationship between three attributes of color and the impression of basic tastes quantitatively.

OS10-4

The Color Image of Dichromats and Anomalous Trichromats

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ABSTRACT

The color image of four male color vision deficients, one protan, one deutan , and two deuteranomats, was measured with 12 SD scales of 7 points. Eleven colors chips of red, orange, greenish-yellow, yellow green, bluish-green, greenish-blue, blue, purple, white, gray, and black which were selected from the New Color Collections of the Japan Color Research Institute , were attached on a black background sheet. Those colors were observed one by one by the participant through a square opening of black mask to avoid mutual influence between adjacent colors. All the stimuli were observed under natural fluorescent lights with chromaticities of (.364, .379) and the average illumination was 842lx.

The results were averaged for scarceness of participants of color vision deficiency and compared with average results of 13 participants with normal color vision.

The results were summarized as bellow:

For red, images of "activity", warm-cold, thick-plain, dynamic-static, and crowded-lonely shifted towards right in the color deficients compared to color vision normals. Images of "modernness", elegant-bulgar, romantic-realistic, modern-ancient, young-old, smart-rustic were unchanged. Orange showed similar shifts.

For yellow green, images of almost all scales were shifted towards right in the color vision deficients. For colors of bluish-green, greenish-blue, blue, purple, and gray, images of color vision deficients did not show great change. For greenish-yellow, images of "modernness" shifted towards right in the color vision deficients. Images of white were unexpectedly different from color vision normals in that the points shifted towards right in several scales. The images of black and purple were generally similar to those of color vision normals showing differences in some scales.

As a whole, it can be concluded that images of “activity” were greatly different from those of color vision normals. The images of bluish colors did not show great change as expected from color vision theory, but yellowish color showed relatively large shift in the color vision deficients. Selection of colors may be concerned with these results.

Abstracts

MCS Oral Papers

MCS1-1

Surface Spectral Reflectance Estimation with Structured Light Projection

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ABSTRACT

Several solutions were developed to reconstruct reflectance spectra of surfaces. Most of them focus on 2D acquisition of more than three spectral channels. The bands are separated by filtering the illumination spectrum or the light falling on the camera sensor. Recently more complex solutions have emerged, which combine the multispectral information with shape in 3D. We present a robust method of spectral reflectance estimation for points sampled on a 3D surface in a structured light projection system. The proposed solution does not need any additional hardware apart from the devices used in the classic structured light projection setup. It utilizes a calibrated color CCD camera and a DLP projector, which projects sine fringes in order to provide precise 3D point coordinates. Additionally, the projector is used as a light source for multispectral image capture by displaying uniform color fields. Simultaneous acquisition of the 3D shape information, as well as the multispectral data is possible in a single sequence of images. They are corrected for illumination non uniformity, ambient light and camera noise.

Two approaches are verified for the design of optimal projected hues. In the first one the saturated RGB or CMY fields are displayed. Principal components with the most variation from the resulting 9 channels registered by the camera are taken as input to the spectrum reconstruction algorithm. In the second approach three hues are found by an optimization algorithm which uses emission spectrum of the projector and quantum efficiency of the camera in order to minimize intensity variations between channels.

The presented method reconstructs a point cloud representing the surface with spectral reflectance estimated for each point. Two tested methods of spectrum reconstruction are the Wiener inverse and the PCA based approach. We provide evaluation of accuracy of the proposed method and show results of scanning painting samples created with different techniques, as an example application of cultural heritage digitization.

MCS1-2

Multispectral Imaging System Based on Tuneable LEDs

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ABSTRACT

Multispectral imaging is preferred over conventional RGB imaging because of high colour accuracy, non-metameric match and is not limited to visual range. Typically, multispectral imaging systems are developed using filter wheel, filter array, stereo camera or monochrome camera with multiplexed illumination which are expensive and time consuming methods. Much attention has been paid to the multiplexed LED illumination based systems during last decade because of its robustness, high switching capability and cost effectiveness. A modified multiplexed illumination system was proposed using RGB camera and LED illumination by Shurestha et.al.(2013), which used RGB camera and different combinations of RGB LEDs. They evaluated performance of their developed system by considering results of a hyperspectral camera (HySpex-VNIR 1600) from Norsl-Elektro-Optikk, as ground truth.

In the current work, a system was developed based on the same idea, optimised for its performance and compared with a commercial hyperspectral imaging system (Hyper-spectral Microscope with EMCCD camera, VNIR-400~900nm) from Isuzu Optics. Isuzu Optics used line-scan and Push-Broom technology to obtain hyperspectral imaging. This technology is more robust and has less acquisition time in comparison with filter based methods. The Isuzu system was tested

first by capturing different targets and its performance was found excellent. In the developed system, a 16-channel LED illumination system, individual channel of which is controllable through computer software, was used. Nine narrow band LEDs within the visible spectral range (400-700nm) and three from each of red, green and blue regions were selected from a total of sixteen. Three optimal combinations each of 3 LEDs (one from each of R, G and B regions) were selected to illuminate the scene. For each light, the scene was captured once using Canon 5D Mark-II camera. These three exposures were used to estimate the 9-band spectral image of the scene using linear regression method. Some further improvements were made like optimization of camera spectral sensitivities, uniformity correction of exposures and assigning optimum weights to different LEDs and training samples. With these improvements the performance of the system was improved to 2.4 DE00 units from the 24 Macbeth Colour Checher Chart (MCCC) comparing with 1.5 DE00 units from the Isuzu system. While that for MCC-SG, DigiEye-DigiTizer and Olio-Painting-Pigments charts, the average colour difference was around 3 DE00 units for the developed system and performed less accurately than Isuzu system by 1 DE00 units. It was found the main errors to be caused by acquisition noise due to non-uniform and low intensity of the LED sources used. New work is carrying out to employ a high intensity LED illuminator to achieve better results.

Some real paintings using both of the systems were also captured. It can be concluded that the developed system is self-illuminated, saves energy because of LED lighting, easily realizable, cost effective(about 10:1) and computationally much faster(about 5:1). Further advantages of the camera based system include zoom, focus and resolution. A MATLAB based software was developed to process data coming from Isuzu system and lightness of dark colours was adjusted which greatly improved overall performance.

MCS1-3

Evaluation of Hyperspectral Imaging Systems for Cultural Heritage Applications Based on a Round Robin Test

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ABSTRACT

The study of the paintings and other artworks that represent the cultural heritage is key to effective and adequate restoration and conservation procedures. There has been an increasing interest in using spectral imaging for cultural heritage applications as it provides scientific knowledge on the materials, and helps to understand artist's techniques. Though the general classification of spectral imaging is based on the number of bands as multispectral and hyperspectral systems, spectral imaging devices varies in several ways depends on the technology used for capturing the data. This includes the sensor, electronics, optics and the imaging conditions also. As a result, spectral characteristics even for the same object imaged using each different device produce different output. In order to understand the suitable devices for varies kind of applications in cultural heritage sector, it is necessary to understand the diverse set of spectral imaging devices. This paper describes the analysis of spectral data obtained from a Round Robin Test (RRT) to ensure the quality and comparability of measurements by participating laboratories. As a part of the EU project COSCH (Color and Space in Cultural Heritage), 16 laboratories are participating in this RRT and each participant use one or more imaging modalities. Keeping the end application as cultural heritage sector, five test targets has been chosen for this RRT and each of these objects has different typologies. The test targets includes a Spectralon wavelength calibration standard, X-Rite ColorChecker Classic, X-rite white reference painted panel reconstructed with medieval Tuscan technique, and antique Russian icon on copper.

Spectral image data obtained from each imaging devices used in the participating laboratories analyzed qualitatively and quantitatively. Influence of several imaging device parameters (sensor characteristics, spectral sensitivity, spectral range, noise, dynamic range, optics, data formats) and imaging conditions (illuminant spectral power distribution, imaging geometry, illuminant non-uniformities etc.) will be studied. The present RRT is considered as an external spectral image quality assurance tool in cultural heritage applications. Results from this RRT will be used to standardize spectral imaging procedures, and also to determine certain characteristics of reference materials which are useful for accurate documentation and analytical studies.

MCS1-4

Spectral Gigapixel Imaging System for Omnidirectional Outdoor Scene Measurement

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ABSTRACT

Omnidirectional imaging is a useful technology for landscape archiving such as Google Street View and The Archiving of "Aftermath of the 2011 Tohoku Earthquake and Tsunami" (a project by The University of Tokyo and Tohoku University). For high-quality scene archiving, it is also important to achieve accurate scene spectral information and high-resolution images. In other words, the technology of a spectral gigapixel imaging system for omnidirectional natural scenes is significant in next-generation natural scene archiving. Thus far, imaging systems have been developed separately as spectral imaging systems, gigapixel imaging systems, and omnidirectional imaging systems with different applications. Moreover, some integrated systems combining two of the abovementioned types of imaging systems have been proposed for specific purposes. However, there are no imaging systems for acquiring spectral, gigapixel, and omnidirectional images concurrently. Therefore, in this paper, we discuss the development of a system for acquiring spectral gigapixel images for omnidirectional outdoor scenes. The system is constructed using two programmable high-speed RGB video cameras with telephoto lenses and a programmable rotating table. The captured image size is 2,048 × 1,088 pixels, and the camera can capture images at a rate of more than 100 frames per second. The lens used is a telephoto lens, which covers a 14.5° horizontal angle and a 10.8° vertical angle. The rotating table can be automatically controlled by a computer. It has 360° movement in the horizontal plane and 180° in the vertical plane. Two different types of color filters are mounted on the two RGB video cameras for multiband image acquisition. By combining these color filters with the camera sensitivities, we can obtain six channel spectral sensitivity functions. Then, spectral power distributions are recovered from the captured six-band images by using the Wiener estimation algorithm. From the experimental results, the average RMSE in the proposed system is estimated to be 0.01427. For achieving gigapixel omnidirectional images, we capture the images in 60 horizontal and 21 vertical directions. Then, we synthesize a gigapixel omnidirectional image by combining the 1,260 captured images. This synthesized image covers a 360° spherical field and has approximately 1.9 gigapixels (60,000 × 32,000 pixels). As a result, our spectral gigapixel image makes it possible to view omnidirectional details and to reproduce accurate spectral power distributions in the scene.

MCS2-1

Handheld Hyperspectral Imaging System for the Detection of Skin Cancer

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ABSTRACT

Skin cancer represents one in three of all cancers worldwide and its incidence in Europe, USA and Australia is increasing rapidly, being the melanoma the most aggressive one. About 90% of skin cancers are caused by ultraviolet light from daylight or tanning booths. The World Health Organization

estimates that 60,000 people die every year for sunlight excess: 48,000 from melanoma and 12,000 from another type of skin cancer. On the other hand, the survival rate in 5 years really increases if the pathology is detected and treated early. Nowadays, visual inspection through the dermoscope is the technique most widely used by dermatologists for the detection of skin cancer. Dermoscopy allows the specialists identifying different structures, patterns and colors of the skin lesions suggesting if they are benign or malignant. This is confirmed by a histological examination later on requiring a surgical extraction of the lesion, which is the gold standard for clinicians. By means of this procedure, a lot of false positives are still obtained and thus, the direct annual costs of diagnosis and treatment of skin cancer are high. In order to overcome these limitations, in this study a new handled hyperspectral system for the diagnosis of skin cancer is proposed. The system consists of a 12 bit-depth monochromatic CCD camera (1280x960 pixels) and an objective lens which allows recording skin lesions with a 15x20 mm field of view. A ring light source containing 32 light emitting diodes (LED) with spectral bands covering the visible and the near-infrared range of the electromagnetic spectrum is used to illuminate the sample. Moreover, two polarizers allow changing the degree of polarization of light and thus obtaining information from different skin depths. This is important as for instance, melanomas can grow deeper than other lesions. In this work, we present the methodology followed to setup and characterize the whole system, including the protocol followed in order to select the most suitable spectral bands to detect skin cancer lesions. Furthermore, the first results corresponding to real lesions analyzed at a clinical site (Hospital Clínic i Provincial de Barcelona and Institut d'Investigacions Biomèdiques August Pi I Sunyer, Barcelona) are also presented here. This work is within the framework of the European Project DIAGNOPTICS "Diagnosis of skin cancer using optics" (ICT PSP seventh call for proposals 2013), the aim of which is developing a multiphotonic platform including hyperspectral and 3D techniques, blood flow analysis and confocal microscopy for in-vivo imaging of skin cancer lesions as a diagnosis service. These technologies are envisaged to improve the detection ratio and the evaluation of the prognosis of skin cancer at earlier stages, compared with the conventional approach.

MCS2-2

Empirical Disadvantages for Color-Deficient People

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ABSTRACT

Trichromatic color vision, i.e. color vision that is based on three distinct different types of photosensitive receptors on the retina of the eye, evolved in humans because it provides certain behavioral advantage as current research suggests. Many scientist emphasize that color especially supports attentional mechanism, object recognition and might possibly facilitate detection of emotions in human faces. Color deficient people, i.e. anomalous trichromats and dichromats, perceive indeed less colors than the majority of trichromatic humans, but they have a color perception that is comparable with, and in many aspects better than, the color perception of the majority of animals that are able of perceiving color.

Color deficient people encounter truly certain problems in daily life both in natural settings – for example when picking berries, determining whether a steak is raw or well-done etc–, and especially in social settings where color coding is heavily used in communication – for example when reading geographic and public transportation maps, or when they are excluded from certain professions that rely heavily on different colored signals, like pilots train conductors etc. On the contrary, some research suggests that color deficient people might even have advantages for certain camouflage detection tasks. However, behavioral disadvantages, or advantages, of color deficient people in natural and social settings is still only marginally researched. More specifically, two main questions remain: What is the behavioral advantage of trichromatic color vision in comparison to dichromatic color vision? And are there measurable behavioral differences between normal sighted and color deficient observers? We argue that color deficient people do indeed have a marginal disadvantage in natural settings, but that main problem mainly arise in social settings.

In this paper, we are discussing three paradigms that can be used to support, or reject, the hypotheses that trichromatic color vision in humans supports attentional mechanism, object recognition and emotion detection, and that can be used to show differences between color deficient and normal

sighted observer groups. The hypotheses can be tested with behavioral experiments involving sample-to-match, visual search, object recognition, object identification object class identification and emotion detection tasks. Moreover, these paradigms can be used to point out disadvantages and advantages of color deficient observers by comparing their results to normal sighted observers.

Secondly, we implemented a visual search experiment (ViSDEM) that is used to compare response times and accuracies for tasks involving the attentional mechanism of normal sighted color deficient observers and color. We found out that color deficient observers have indeed a slight behavioral disadvantage before normal observers.

MCS2-3

Spectral Reflectance Recovery Using Natural Neighbor Interpolation with Band-divided Linear Correction

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ABSTRACT

In this paper, we proposed an accurate recovery method of object spectral reflectance using the traditional natural neighbor interpolation, shortly named as NNI, with band-divided linear correction. Essentially, such a recovery problem was usually to transform the RGB channel values into a spectrum to simulate the reflectance of an object. There were many previous researches offering various solutions to this problem with more or less advantages and drawbacks. Our work improved the recovery result based on the interpolation approach with further correction of spectral reflectance. This new solution proposed not only gives more accurate results, but also avoids the extrapolation problem causing by the phenomena out of gamut.

Our method consists of two stages of recovery procedures. First, the NNI interpolation was used to construct the spectral reflectance from the real samples of color checkers. Eight additional pre-determined spectra were imposed for the corners of the sRGB color space, named virtual extreme spectra, to guarantee all the test samples in the gamut spanned by the known samples; such that, the interpolating scheme worked well without the extrapolation problem. Secondly, the spectra resulting from NNI were further fine-tuned according to the difference between its sRGB color under illuminant of D65 and the original input one of ground true. Three pre-specified wave lengths, denoted S, M, and L, were selected as the control points to correct this NNI spectrum approaching to a new one with less color difference. This correction was composed of 4 piecewise linear transformations related to 4 bands from 400nm to S, from S to M, from M to L, and from L to 700nm respectively.

Some experiments were performed to evaluate the performance of the new NNI with the virtual extreme spectra and the additional correction stage. At first, the 1269 checker spectra from Munsell book was used as the test samples under the training samples from Macbeth 24 color checkers. The largest color difference of delta E2000 was 1.6366 based on the illuminant of D65, and the average difference was 0.0915. And, the color differences were further improved, if the band-divided correction was adopted. Then, the largest delta E2000 was 1.4869, and the average difference was 0.0726. In addition, the entire gamut of sRGB was also evaluated. The spectra recovered from the specified RGB channel values lead to the largest color difference was 1.6671 and the average one was 0.0315 under the illuminant of D65, based on the training samples of Macbeth color checkers. The largest difference was 1.4915, and the average one was 0.0126, based on the training samples of Munsell book checkers. These experimental results showed that the proposed method was very accurate for the recovery of spectral reflectance.

Evaluation of Gastrointestinal Tissue Oxygen Saturation using LEDs and a Photo Detector

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ABSTRACT

In the reconstructive and resection surgery of hollow organs such as the small intestine, determination of the viability is very important. For example, in autotransplantation, a healthy gastrointestinal part of the patient's own organ is resected and used to reconstruct the diseased gastrointestinal part. The surgeon must select a healthy part based on experience before resection and check the viability of the reconstructed organ as well. A major criterion to discriminate the status of healthy or unhealthy is to check the oxygen supply. The oxygen supply is determined by the amount of oxygen in blood and differences of that amount are reflected in the organ color. This determination has been performed by the surgeon's visual inspection. However, since the difference of color between a healthy organ and a poor organ is very slight, the visual inspection for checking gastrointestinal viability is subjective and highly depending on the surgeon's sense and experience. For this reason, quantification of gastrointestinal viability, especially oxygen saturation, is needed.

In MCS2014, we presented a method for estimating the tissue oxygen saturation (StO_2) of gastrointestinal organ by near infrared (NIR) region spectroscopy. We performed animal experiments and obtained successful estimation results. However, a bulky setup for measurement is not suitable for clinical use. In this paper, we propose a different method using some LEDs in NIR region and a photo detector. We determine an organ absorbance model equation based on the Beer- Lambert law and estimate StO_2. However, the absorption coefficients of tissues in organ are unknown. First, we apply the non-negative matrix factorization (NMF) method to the organ absorbance data acquired in advance to retrieve the absorption coefficients of each tissue. Furthermore, we redefine the mean absorption coefficient that is suitable for emission characteristics of the LEDs to correct the error due to the LED emission bandwidth. Using acquired mean absorbance coefficients, we determine the organ absorbance model equation based on the Beer-Lambert law. Then we estimate concentrations of organ tissues and calculate StO_2 by the ratio of oxygen hemoglobin concentration and de-oxygen hemoglobin concentration.

Using transmittance spectra obtained in the previous experiment, we simulated the performance of the proposed method and found that good estimation results similar to the spectral-based method will be obtained by the proposed method. Currently we are designing an optical combination of LEDs and making a prototype of the device. We will present some experimental results using that compact device in the conference.

Abstracts

Poster Papers

PS1-1

Colour Image, Fashion Design and Identity

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ABSTRACT

The Color, Art and Fashion design concerns the Harmonies of color associations of textile and other materials used for couturier's aesthetic project. It is an illustration of collaboration of artists and couturiers on the harmonies of color associations in order to create a personal style and marque or brand identity. They were more closely tied at the turn of the 20th century than they are today. Artists did not see the difference between creating an original work of art, such as a painting, and designing a textile pattern that would be reproduced many times over. Each was a valid creative act in their eyes. There are a lot of vivid illustrations of the centuries-long love affair between fashion and art of color. Couturiers are past masters at capturing the contemporary zeitgeist in their designs, while artists have frequently used clothing as a way to give all-round expression to their aesthetic ideas.

Beginning from the 19th century major changes both emerge in the role of fashion and in the place of art in society. Growing affluence and new social structures gradually turned both fashion design and art of color into ways of expressing personal taste and identity.

Our study raises a historic panorama of the color in the fashion design during the XXth century, highlighting certain symbolic movements such as the Art nouveau, the Russian avant-garde, the modernism, pop art or the kinetic art. It lists the colour's harmonies for modern fashion design and describes the tools, ranges, palettes, techniques which allow personalizing a dress with fantasy and subtlety.

Art has often been a major source of inspiration for dress designers of XXth century: we remind some creations by Paul Poiret, Sonia Delaunay, Liza Schiaparelli, Coco Chanel, Yves Saint Laurent and Givenchy. In their practice art of color is in fashion image. The designers paraphrase the masters of painting.

This connection between art and fashion is obvious from the end of XIXth century. Nowadays, the collaboration between artists and fashion designers continues. The personal artist's inspiration of French colorist Larissa Noury comes from her own color harmonies of tactile painting, from within. Jean Marie Pujol, couturier who worked with Dior and Yves Saint Laurent at the time, designed several dresses to be painted by L.Noury. Their unique collection of painted dresses means to perpetuate the art and fashion marriage in order to create an original color image.

PS1-2

Contemporary Art and the Unfoldings of Colour

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ABSTRACT

Contemporary art legitimates color by leading it away from the traditional techniques of painting, and it transgresses platforms by thinking about new modalities of image: it puts the spectator and the space as central elements of the chromatic experience. Color is the sensation given by the image – and the latter is no longer assimilated from traditional constituents (canvas, paint) – in installations and urban interventions. The passengers on streets and avenues are captured by the unexpected, and color is inserted within the city's landscape as a sensorial input to be perceived.

From the 60's onwards, the role of color on the realms of contemporary visuality has been deeply rethought by art. Carlos Cruz-Diez (Venezuela), Hélio Oiticica (Brazil) and Daniel Buren (France) are leaders of this conceptual turning point: they established new chromatic formulations for installations and interventions; they made color a way of awaking within the spectator the everyday

sensitivity and the attention to the landscape. For them, color shows the space in its social nature, as Oiticica affirmed, “color is the first revelation of the world”.

Cruz-Diez, Oiticica and Buren inserted color into the paradigms of urban space construction and institutional art centers. They prioritized art in a three-dimensional plan: architecture and color are integrated in visual culture. Color, life and experience do not clash, they are united in the attempt of reestablishing and updating the audience’s vision. On this presentation, I will particularly discuss Cruz-Diez’s Cromosaturaciones, Inducción Cromatica and Color Aditivo, Oiticica’s series Penetrável Magic Square and Buren’s Affiches Sauvages and Papiers Collés, works on which the value of color is somehow recreated in image and contemporary culture.

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PS1-3

Comparison of Slovene color identities by researchers A. Trstenjak and M. Tusak with colors on Slovenian municipality flags

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ABSTRACT

Combinations of specific forms and colors represent most effective method to distinguish between different identities. When forms (objects, items) are similar or even identical, then only colors remain most reliable discriminatory factor.

Medieval time in Europe were mainly dominated by the general illiteracy and forms of visual identities such as shields, coats of arms and flags, which were important to unambiguously distinguish the different actors - especially when they have emerged as opponents in fighting or games, or any expression of belonging, labeling property, possession, etc. In 11th century, when designing coats of arms and flags, a series of disciplines from heraldry, vexillology, sfragistics, insigniology, iconology emerged, which were applied among philosophical sciences at that time. However, today they are complementary Sciences of Art History.

The aim of this paper is to present colors, appearing on Slovenian municipality flags at present and to compare them with the findings on Slovenian color preferences by psychologist Anton Trstenjak 40 years ago and by psychologist Max Tusak around 20 years ago.

In last fifty years Slovenia gained a multitude of new flags appeared due to new municipalities on the basis of local features or attractions which were designed in accordance with modern trends in design. On the other hand, part of the municipal flags represent the heritage of the past, their historical traditions and well-known local attractions, etc. These “older” flags are generally based on heraldic and veksilological principles.

The three studies were done in different time frames, separated by decades. Psychologist Anton Trstenjak presented the colour preferences of Slovenian population on a sample of 1,000 students in secondary schools. Psychologist Max Tusak, who worked with Anton Trstenjak, has carried out two decades later, a similar survey on a sample of students in four different types of secondary schools. In the third study, decades later, we made a research of the colours on Slovenian municipality flags, which represent colour preferences of population in a given environment. Some structural analysis of colour histograms was performed to find out representation of the colours in the flags. The results were given into the Periodic colour model to comparatively analyse current state and illustrate the changes. In final study we found a lot of differences and changes over time in colour preferences among decades, but we found also exception, mostly concerning similar preferences in colour blue.

PS1-4

A Comparison of Color Schemes and Images in the Package Design of Sweets in the US and Japan

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ABSTRACT

This study compares the color schemes and design of packages of sweets in the US and Japan from the viewpoint of the color culture. To visualize this comparison, color charts representing typical Japanese and American sweets packages are presented. The central aim of the comparison is to clarify cultural differences in color that characterize appetizing sweets, between the US and Japan. The study investigates whether there are perceptible differences in the color scheme of the package design in the US and Japan, and if any, how different are they in the three color attributes of hue, value, and chroma.

The research method was as follows: I purchased a total of 120 items, 20 items each of hard candy, chocolate, and chewing gum sold nationally, both in the US and Japan in 2013-14. Using the colorimeter for color management, I measured the color scheme of these packages and listed the data in the form of color charts. These data are significant in revealing the fundamental cultural differences in the package design in these nations, a valuable insight for the field of international marketing and graphic/package design.

Japanese food culture has been recognized as unique in the global market, producing new items annually. In the late twentieth century and the twenty-first century, Japanese products and culture, such as sushi, anime, and automobiles, have been globally recognized. However, in the US and Europe, people still seldom see Japanese candy, chocolate, and chewing gums in local supermarkets, except in Japanese groceries.

Mostly, there is a strong tendency for Japanese sweets packages to use a warm and light grayish color scheme, whereas American ones apply a vivid multicolor scheme. Japanese sweets manufacturers produce various novelty items that promote seasonal and regional marketing, whereas American mass-produced sweets and its coloring are generally aimed at children and their dreams. Therefore, the color scheme of and the images on packages of US sweets resemble American comics.

PS1-5

Human Monochromatic Impressions on Multichromatic / Colorless Phenomena and Concepts

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ABSTRACT

This research experimentally investigates human preferences and bias on colors by visual impressions. We made experiments on asking the participants a single color on each of phenomena and concepts, presented by words, based on their impressions. The importance of this experiment is observing what a single color is selected to express each of the phenomena and concepts which are essentially difficult to express by a single color. The results are expected to reflect how a single color is selected based on human impressions, preferences, and bias.

The presented words are: "summer", "internet", "dream", "water", "time", "air", "hot water", "wind", "winter", and "rainbow". The participants are all Japanese, and the words were presented in Japanese language. The number of participants is 107.

Two interesting observations are shown in the following:

1) None of the participants answered "green" when the single color of "rainbow" was asked, although green is physically obviously observed in the spectrum of the rainbow and other various colors were answered. Only one participant answered "yellow green." Many participants answered "orange," "yellow," and "purple," and it is understandable since they have a good contrast to the background blue sky. However, "blue" is sometimes selected but "green" is not selected at all,

although green is surely found in the spectrum of the rainbow and it is clearly distinguishable from the background blue.

We estimate that the reason of this result is because green is adjacent to yellow in the rainbow and yellow is more stimulative than green. We made an additional simple experiment to support this. We showed participants an artificially drawn color stripes containing the same colors appearing in the rainbow but the arrangement was interchanged. Even when it was shown on the blue background, a few participants selected "green" as a single-color answer to express the stripes.

2) The answer of almost all the participants to "winter" is "white." The participants are mainly from western side of Japan. Since it does not snow so much in winter in this region, the winter scenery in this region is actually not white, but rather brown because of the defoliation of trees. It is estimated that the impression is not from their experience but from their knowledge.

PS1-6

How to Create a Colour Education that Fosters Price- winning Design Students

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ABSTRACT

How to create a colour education that fosters price-winning design students?

An example from the Linnaeus University in Sweden.

Background.

The colour education of today is an important building block for all future design. If we can provide our students with state of the art colour education we will get the best future design when it comes to the use of colours. That will include all kinds of design e.g. graphic design, architecture and product design.

In 2014 there was a national competition called Awarded Colour, organized by Swedish Colour Centre Foundation that celebrated their 50 years anniversary. The competition was open to all students of design, architecture, fine art graphic design and advertisement. Design students from the relatively small product design programme at the Linnaeus University won two out of three awards.

A prizewinning concept for color education.

The subject of colour is introduced very early in the programme.

Students of product design have two weeks of colour theory and workshops in their first semester. In this basic theoretical course the students get to know different colour systems and the advantage of using systems to think, visualise and communicate colour. In the workshops they can train their eyes and skills in mixing and combining colours with an increasing degree of complexity. The workshop ends with a task where students explore the use of colours in different contexts such as art, architecture, visual communication, design and in other cultures.

This lays a ground for four more weeks of colour projects with a researching approach. The students phrase their own colour questions and seek answers through research and visual colour representations. In the second year there is a progress in understanding different contexts of colour. The students continue with light theory and light projects for five more weeks and then proceed with light and colour in space contexts for another five weeks.

To ensure that the students will train and use their colour skills throughout their entire study period the students are asked to present and motivate the chosen colours in every project they do. That makes them always remember that the aspects of colour are as important as any other design aspect when it comes to the visual expression.

The students are also asked to participate as subjects in colour research projects to make them aware that colour research is a huge field with many disciplines involved and many questions emerging from their colour studies can actually be research questions and lead to colour research projects.

The three-fold strategy, early introduction, emphasis on colour and continuous progression, has proved to be successful. The fact that students from the product design programme at Linnaeus University could win two out of three awards for best colour design is a clear indication of that.

PS1-7

Influence of Odors Function and Colors Symbolism in Odor-color Associations: Comparative Study between Rural and Urban Regions in Lebanon

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ABSTRACT

It is well-known that culture-specific experiences may strongly influence basic aspects of odor perception (Ayabe-Kanamura et al., 1998). Differences in terms of odor-color association might therefore be culturally specific. Consistent associations between specific colors and odors mainly related to food have been confirmed recently (Maric & Jacquot, 2013). It is well known that culture-specific experiences with odors may influence different aspects of odor perception such as intensity, pleasantness or edibility. Previous studies have demonstrated significant differences in odor-color associations between French-Lebanese and Taiwanese groups. These results indicated that these differences could arise from cultural differences in the odors function (especially in terms of edibility) and colors symbolism (Barbar, Maric and Jacquot, 2014).

The purpose of the present study was to assess the cultural impact on the relationship between odor and color on one hand, and on the parameters of the smell on the other hand, within the same country, Lebanon, unlike preliminary studies that evaluated the cultural effect between two different countries. To assess this cultural effect, sensory analyzes were performed on 200 subjects in two Lebanese regions: Zahleh representing the rural community, and Kaslik representing the urban community. The experiments were based on a set of 18 odors, some of them are internationally recognized, others nationally, and some mainly recognized in the rural areas. Statistical analyzes revealed a cultural impact, given the existence of significant differences for some odors: Shallots score the biggest difference, where it is recognized in the urban area, and therefore the choice of color is more appropriate. Caramel, smoke, orange blossom, molasses and Jellab (the last two being national Lebanese odors) also show significant differences in color choice between the two regions. Similarly, scores of familiarity, of intensity, pleasant ness and edibility indicate some differences for few odors. These sensory analyzes have shown for the first time the impact of culture on the relationship between odor and color, between rural and urban areas.

PS1-8

Differences of Generation Dependences of Preferences between Colors and Styles in Women‘s Fashion

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ABSTRACT

This research investigates generation dependence of preferences in fashion, and shows the difference of dependences between colors and styles of dresses.

It has been widely indicated that the preference of the color in the fashion is different by the age group. However, it is said that the preference in fashion of forties’ women has recently become less different from it of twenties. We assume the tendency of age independence is found not only in the fashion-style but also in the color preference of fashion. In this paper, we have investigated about the preference of twenties students and their mothers, who are generally forties, in the fashion-style and color of fashion.

The participants of the experiment are 200 female university students and 60 of their mothers. We made a questionnaire on the preferences of colors and styles of dresses. Preferences of colors were surveyed, by selection from 16 colors including monochromes, on each of the tops and the bottoms, and preferences of styles were also surveyed on the details of the tops and the bottoms, e.g. shapes and lengths of skirts, sleeve lengths, etc. Preferences on spring-summer and autumn-winter dresses were separately surveyed.

As a result, a significant difference was confirmed in the fashion style between the student generation and the mother generation, especially in the taste of characteristic parts.

However, it was shown that any significant difference was not confirmed in the color preferences, although some difference was observed. It has been usually said that elderly women prefer dark and dull colors, however, according to our surveys, young students also preferred monochromes, especially in autumn-winter dresses. Mothers group also preferred bright colors, especially in spring-summer ones, similarly to the young students.

PS1-9

Effect of Color Appeared in Signage to Identify Gender of Thai

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ABSTRACT

This research aimed to study the effect of color appeared in signage to identify gender of Thai people. Colors used in this study were light blue and dark blue, identified as male; red and pink, as female and black as neutral color. Two symbols, as for male and female, were in aforementioned five colors. So the total was ten images. These symbol images were showed within 2 seconds. The subjects of this study were 50 students of Rajamangala University of Technology Thanyaburi. For the first evaluation, the subjects assessed the color of the symbols whether or not that color was identified as male or female. For the second evaluation, the subjects assessed the details of the symbols whether or not they were male or female. Then these two evaluations were compared.

The expected result will be able to identify gender of Thai people from signage. The details of the symbols, compared to the color of the symbols, can be used to identify the gender more efficiency.

PS1-10

Development of Three Primary-color Transparent Cubes for Learning Subtractive Color Mixing Visually

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ABSTRACT

Color mixing can be divided into additive color mixing and subtractive color mixing. The LED devices have been rapidly spreading in our everyday life. As such, we can easily recognize that R, G, and B lights are three additive primary colors, and that white color is made up by equally mixing the three additive primaries. On the other hand, subtractive colors used in photography and print are in unfamiliar colors CMY. As the experience of subtractive color mixing is only painting in art class of school in his youth at most, there is no chance that almost can feel in everyday life. Thus, to feel subtractive color mixing more familiar in daily life, we wanted to develop visual materials that help to learn the color mixing.

To visualize the subtractive color mixing, focusing on three pairs of combinations of the parallel surface and the three primary colors of the cube, we use the cubes that are liked as a building block. We colored surface of the cube in the three primary colors (which are colored in the same color the

two parallel sides), and by devising the internal structure of the cube, the same shape but different appearance of three primary colors cubes are produced, named (1)shell type, (2)core type, (3)core-shell type.

(1)shell type:

By mixing two adjacent surfaces (C, M, Y) primary colors, (R, G, B) can be observed. Six colors (R, G, B, C, M, Y) can be also observed at the same time.

(2)core type:

By filling the cube of transparent material, mixing of adjacent primary colors (C, M, Y) can be observed like beautiful rainbow, and rainbow pattern changes in the angle of observation.

(3)core-shell type:

Using the new optical design which color mixing of adjacent faces does not occur, we can form the three primary colors RGB cube by stacking 8 [2x2x2] CMY cubes. In addition, by stacking CMY and RGB 64 cube [(2x2x2)x2x2x2], Black (C + R, M + G, Y + B) also cube can be formed.

By touching these cubes as puzzles and building blocks visually, or questioning in each of the cube of the difference, it is considered a useful teaching materials to help you understand the subtractive color mixing and geometric optics. The announcement day, these three primary colors cube was exhibited at the poster session venue, we report on the characteristics of the optical design and appearance of cubes.

PS1-11

Multicolor LED Lighting Device with a Microprocessor for Demonstrating Effects of Lighting on Color Appearance

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ABSTRACT

The author has assembled several versions of multicolor LED lighting devices to demonstrate effects of lighting on color appearance. An elementary version was controlled with mechanical switches for selection of lighting LEDs. This version was adequate for demonstrating metamerism.

Next version was equipped with 5 mechanical switches for each LED to control lighting level. This version could provide variety of color mixture, but the wiring was complex and hard to assemble. Another problem was usability: to obtain several lighting conditions, the operator had to readjust many mechanical switches.

To avoid the above difficulties, the author employed an Arduino Mega 2560 microprocessor with 54 digital I/O pins of which 15 provides 8-bit PWM output. As the result, the device acquired simpler wiring and smart operation. The programming of Arduino is easy to learn with adequate references available from web sites and books.

This device employs 11 Philips LUXEON Rebel chip LEDs: deep red (λD = 655nm at 350mA), red (λD = 627nm), red orange (λD = 617nm), amber (λD = 590nm), green (λD = 530nm), cyan (λD = 505nm), blue (λD = 470nm), royal blue (λD = 448nm), cool white (6500K), neutral white (4100K), and warm white (3100K). Controlling these LEDs with 8-bit PWM, and using control panel with arbitrarily designed rows of push buttons, we can present any pre-set mixture of LED lights.

There are some difficulties in fabricating with chip LEDs. First, chip LEDs are so small that tweezers are necessary to manipulate under a magnifying glass. Second difficulty is due to the fact that chip LEDs are weak to heat; they have to be soldered with temperature under 300 degree centigrade. The author employed the reflow technique in soldering thermal pads and anode pads of LED chips.

Since LED chips allow maximum current of 1A with voltage around 3V, maximum power dissipation is estimated around 3W per LED chip if 1A flows. The author designed so that the maximum current will be around 0.5 A. With this maximum current, the device will produce heat near 20W that will match the heat from soldering iron. Therefore, the heat radiation is an important problem.

The author will show how to overcome these problems in addition to the device demonstration.

PS1-12

The Effect of Environment Colour on Behavioural Inhibition

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ABSTRACT

The interplay between colour and behavioural inhibition (a trait of impulsivity) has yet to be researched despite the growing interest and activity in the field of impulsivity and behavioural inhibition (Webster and Jackson, 1997). The implications of gaining a better understanding of this area will help improve crime prevention strategies, the use of colour in marketing, the design of environments and product development. For example, in Japan and, recently, in the UK blue lights have been installed on railway platforms to discourage suicide attempts. However, the robustness of research into the veracity of claims about colour and impulsive behaviour remains to be tested.

This study addresses this by conducting a preliminary experiment in this area. Participant's behavioural inhibition was measured using error rates and reaction times gained from a computer based Go/No-go signal task within in a pop up colour studio. The luminance and chroma of the lighting environment was kept constant but the hue was manipulated between red, blue and green using a 24-bit LED stage lighting system; a white control lighting environment was also used. Results obtained through one way and mixed design ANOVA's found that: In the red light participants task reaction times were signi¬ficantly faster than under white light. Highly impulsive participants showed signifi¬cantly slower reaction times under all conditions except for green where a significant interaction was found. A significant main effect of colour and gender was found with female reaction times having greater variation across all conditions compared to males. Additional work is underway to replicate the preliminary study using more advanced psychophysical techniques.

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PS1-13

Influence of Light Incident Angle and Illuminance Intensity on Visual Comfort and Clarity

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ABSTRACT

In recent years, research into the effect of LED light on human visual response has attracted enormous attention. Efforts have been made in investigating the relationship between environmental factors of LED lighting and the induced visual responses. However, little was known regarding the influence of the combination of light source position and illuminance intensity on visual comfort for reading/writing. The issue is essential for lighting design, particularly for lighting in a cabin of an aircraft or in a patient room.

To address the issue, two psychophysical experiments were conducted in a darkened room, with a size of 42cm (height) by 222cm (width) by 230cm (depth). Thirty-four Taiwanese (including 17 males and 17 females) participated as the observers in both experiments. Half of the observers were over 175cm and the other half below 165cm. All of them have passed the Ishihara test for colour deficiency.

In Experiment 1, each observer performed a writing task on a matt ISO paper placed on a flat panel, with a tilt angle of 45 degrees, lit by a wall-mounted directional LED luminaire with a fixed CCT of 4000K and illumiance of 500lx. This luminaire was positioned above the observer's head. The position of the lamp varied horizontally by changing the angle of an adjustable folding arm that supported the lamp. This resulted in 7 angles of incident light on the writing panel: -24.45, -22.50, -14.40, 0, 14.40, 22.50 and 24.45 degrees. In Experiment 2, the incident angle of light was fixed at 24.50 which was found to create the greatest comfort according to Experiment 1. The illumiance levels included 600lx, 900lx and 1200lx. The same group of observers performed a reading task on the same paper and the same panel as in Experiment 1. Both experiments used 6-point forced-choice

scales in terms of comfort and clarity.

The experimental results show that the position of the LED light had a strong impact on the observer response in terms of comfort and clarity. The perceived visual comfort and clarity was found to increase as the angle of incidence becomes larger and larger, indicating a tendency that the observers (all right-handed) had higher visual satisfaction when the lamp was situated on the left hand side than on the right hand side. Although there was no significant difference in visual clarity between the three tested illuminance levels, 900lx was rated the most comfortable among the three illuminance levels. This indicates that uncomfortable illuminance does not necessarily cause a decline in visual clarity. The research result is useful for lighting design in indoor environments.

PS1-14

Colour Terms in the Interior Design Process

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ABSTRACT

Colour is a very important topic that interior designers need to consider. Considerable research has been conducted in the area of colour application in interior design; in this study we are concerned with colour terms in interior design, mainly the terms designers use and know about. Fifteen interior designers with varied professional backgrounds, but based in the Middle East (Saudi Arabia, Dubai, Bahrain, Lebanon, Egypt and Turkey), were interviewed. Previously we reported that fourteen out of fifteen designers stated that colour thinking and decision making take place at the early stages of their design processes; eight of them reported that colour takes place in the first step when meeting clients and starting the project (Attiah et al., 2013). This study documented 137 terms which the fifteen designers use whilst brainstorming and working on a design project; subsequent analysis of these terms could form a basis for understanding how interior designers communicate the abstract properties of colour as part of their design processes. In this paper we show how the 137 terms were categorised according to a framework of four categories of colour terms: emotional, descriptive, cultural and functional. In addition, some technical terms, which are widely used in colour science (such as CIELAB and saturation), were shown to the designers; their knowledge was shown to be incomplete.

PS1-15

Effects of Classroom Wall Color on Students

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ABSTRACT

The area that separates and limits between architectural components and space is called physical environment. The physical properties of any space may role as limiting, guiding, focuser, combiner and separator for users. These properties are more important especially in classrooms where educational activities take place. In other words, it is a known fact that properties of physical environment act as stimulus and affects student's behaviour and learning performance. The physical environment factors playing significant roles in achievement and reaching educational goals are size, heat, sound, light, color.

There are several research studies in the literature that have explored and determined the effect of the interior surface colors on the users. However, these studies were generally conducted in offices and living rooms and with adult samples. Unfortunately, there is limited number of studies investigating color preferences of children in real space who are within the range of 7-11 years of age and in their 'concrete operational cognitive development stage. In addition, these studies explore by showing small colored samples.

In this paper, the results of an experimental research study which investigates preferences and opinions of 8-9 years-old subjects on their classroom's wall colors will be presented. The steps of this research study are given below:

- Selection of classroom wall colors
- Painting the wall of the classroom with these selected colors each week
- Determining students' color preferences and opinions about each classroom wall color

Five major colors (5R 7/8, 5Y 7/8, 5G 7/8, 5B 7/8, 5P 7/8) were selected by using Munsell Color System. Architectural elements in the classrooms are hidden by covering with grey fabric so that these don't affect the wall colors. The selected colors were painted on the walls in each subsequent five weeks. The students have had lessons under different wall colors in these five weeks. The subjects' opinion and preferences were collected through a semantic differential scale survey for each wall color.

In this context, one private and one public school located in the same district of Istanbul were chosen. 39 female and 39 male, in total 78 students at the age of 8-9 have participated in this study.

PS1-16

A Study on the Evaluation Process of Facade Colour Parameters

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ABSTRACT

Façade colour is one of the most important factors affecting the architecture of the building and the appearance, image / identity of the settlements. Therefore, any decision/determination about the façade colour of a building change the appearance and image of both the building and its environment. Contemporarily, many material alternatives for facades has been emerged due to the improvements in the building and material technology along with the increased painting opportunities. Furthermore, in the design process façade colour is being determined according to the the likes / preferences and personal desires of architects, occupants, employers, etc. without caring the environmental parameters and colour perception factors in practice. Thus, an excessive range of façade colours appear in cities causing inharmonious colour appearances and colour pollution in settlements.

To avoid any inappropriate situations due to colour pollution in the design process, building façade colours should be determined considering factors such as architectural and environmental (natural and built) features as well as colour perception. But in practice, complex relationships of related factors constitute a major problem for the colour designers, architects, etc.

Although there are a range of important studies examining the façade colour design and the effects of related environmental and perceptional factors, the holistic approaches for the whole façade colour design process are very limited.

Therefore, a systematic façade colour design approach for various scales including all the stages has been developed as a Research Project at Yıldız Technical University. This paper basically prepared with the aim of introducing the developed façade colour design approach which is constituted of several stages, mainly includes a detailed analysis of the first stage of the Research Project.

The first stage contains the determination of priority regions and buildings on the colour planning process, according to the evaluation of the effects of the environmental parameters for different settlement scales. For this determination, environmental parameters that effect the façade colour design have been established, then these parameters have been evaluated within the context of urban appearance and façade colour design. For the evaluation of the parameters, a survey has been conducted to educated people at architecture, urban planning, etc. The parameters have been ranked and graded according to the survey results in terms of the effects on the urban appearance and façade colour design.

PS1-17

Correlation between Personal and Classroom color Preferences of Children

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ABSTRACT

The appearance and perception of colors make a strong impact on us in our daily lives. Our emotions, actions, perceptions, performances and health are influenced by colors of the environment. The perception of color and the selection of color –color preference- are two divert subjects. The selection or preferences of colour depends on the age, sex, education, interest sphere and individual preferences as well as culture, traditions, religious factors, fashion, social phenomenon, local and geographical conditions. The negative and positive reactions of people towards colors are stimulated by how much the colour fulfills the expectations of the perceivers.

The color preferences of people differ based on the objects they use and spaces they live in. For example, a person can prefer 'purple' for their outfits, and they can opt for a different colour while purchasing a car, decorating their office or painting their bedroom walls. As people age, their tastes and choices evolve in years, which results in a change in their color preferences.

In this context, a research having two steps have been realized to investigate the correlation between personal and classroom wall colour preferences of children aged between 8-9 years has been set off. The first step was carried out in 2012 in two different primary schools with 119 students in total. As a second step, in December 2013, based on the preliminary research findings, a survey about the personal and classroom wall color preferences of students was performed in the same schools. 74 female and 78 male, 152 students in total were involved in the survey. The latter research survey sampled 10 hues with different values and chromas and in total 84 different colors; all developed based on the former survey results. Through these colors, the correlations between the individual and classroom color preferences of the children were determined, examined and questioned.

PS1-18

Research on the Coexistence of Color between Buildings and Exterior Advertising that Create a Cityscape ~ focusing on the Okamoto district of Kobe ~

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ABSTRACT

In line with the Landscape Act of 2004, the Exterior Advertising Code was revised. At the same time a new concept was put into place which includes not only improving aesthetic and scenic beauty but also a constitution of a more favorable cityscape. There are a number of issues regarding the Exterior Advertising Code such as illegal signboards, restrictions on surface area, as well as a delay in adjusting rules to rapid technology innovations. However, in order to create a more satisfactory cityscape, more and more color restrictions are being placed throughout the country. Indeed, many municipalities have implemented restrictions on high color saturation for signboards. But could it be that simple? There should be a way to create an even better and more attractive cityscape by incorporating the colors of exterior advertising. Therefore, we reconsidered and studied the possibilities of a coexistence between the colors of buildings and exterior advertising.

The survey was conducted by focusing on a mixed commercial and residential area in the Okamoto district of Kobe, Japan. We conducted a fact-finding survey on the colors of buildings and exterior advertising in the district as well as a meeting with the Beautiful City Okamoto Council that drew up "the Exterior Advertising Rules and Guidelines". As a result, we were able to find out that with respect to the local color of the buildings in the entire district, some cityscapes are actually being harmonized with the colors of signboards. Therefore, it is conceivable that the colors of signboards do not prevent a landscape from forming scenic beauty, rather they become an important factor for beautification.

It has also been recognized that this result was supported by the initiatives of the local residents who led the town planning over many years to formulate the guidelines for conforming the colors of exterior advertising.

PS1-19

Colour Management in the Colour Design Process

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ABSTRACT

Colour management in the colour design process in all manufacturing industries are changing due the development in technology and the change of needs from the end customers. With todays widely available colour measurement technology there are no secrets when it comes to the colour shades used by different industries as well as paint companies. Also with the higher demands from the end customers to expect the availability of any colour they want, the number of colours are escalating for different products in general, and for the coatings industry in particular, with number of colours exploding in the paint companies databases often with the consequences that colours are more or less visual identical but having different names.

By taking a more holistic approach to the management of colours in the colour design process and using a scientific system as a platform there are many benefits when it comes to make the colour design process more efficient and by doing that to save time and money in the management of colours. The starting point in that process is how to make a useful analysis of existing colours, both with digital applications as well as visual adjustments and comparisons with other colours on the market with the aim to develop a range that can deliver all the colours that is necessary for a market success.

This will also result in quality improvements and a more understandable offering of the colour range to the end customers.

This paper will present some case studies examining the importance of this holistic approach in the colour design process and how that result can be developed into more useful colour collections.

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PS1-20

Exploring Combinations of Color Patterns in Nature

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ABSTRACT

In recent years the philosophy of Biomimicry is in increase, Biomimicry states that Nature is a result of 3.8 billion years of evolution, provides us with an infinitely rich combination of wisdom and beauty. We can obtain observing, exploring and imitating Nature strategies to solve any kind of problem we could have. That is why many researchers of any field of science and art base their studies

on its creations.

One fundamental principle of nature is the optimization of resources, obtaining more with less. Specialists in Nature studies state that most objects in nature respond with functions according to the context that defines them, in the most economical manner. So, in nature there are not coincidences, everything has a reason to have a kind of form, structure, movement, texture, odor, color, reaction, and so on.

Within this body of information that surrounds us, we find the Lepidoptera (butterfly and moth) egg, caterpillar and it metamorphosis throughout cocoon to become adult, a source of inspiration with a great potential for yielding results to apply to product and graphic design.

In Japan exist around 5800 variations of butterfly and moth, around 300 hundred are butterflies and the remainder are moths. This project illustrates the scope of some of those Lepidoptera color patterns, which provides a wide variety combination of colors many of them difficult to imagine, that is why those invites us to deepen on them. The environment around them is the reason of they coloration, to camouflage or to draw attention to one objective: survive.

The center of the research is to study some species that have bright colors to flaunt in the context, in the other hand some ones that pass unnoticed by its neutral colors. Information as the color of the food they take, eggs, caterpillar, cocoon and butterflies and moths are collected from many source to obtain a comparative graphical table of patterns color combination that they have, the objective is to design a pallet of color patterns as a tool useful for original creations for graphic and industrial design products, useful on daily life and suitable to different environments as hazardous, quiet, modern, classical, cheerful, sporting to mention some.

PS1-21

Visual Impressions Induced by Colours of Facial Skin and Lips

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ABSTRACT

There have been studies into visual impressions of skin tones and make-ups. For instance, Zeng and Luo found in 2011 that the preferred skin tones for Oriental and African faces were more reddish than real skin tones. The common flaw of such studies, however, was in the method of generating visual stimuli, i.e. the visual stimuli were selected or created without controlling any factors that might affect the visual results, such as age, facial features (e.g. eye size) or facial expressions. Without any control of these factors, it would be hard to justify whether the results were based solely on skin tone or whether they were impacted by other factors. For this reason, the present research conducted two psychophysical experiments based on one original face image, which was manipulated by colour, in order to investigate visual impressions induced by facial colours including colours of facial skin and the lips.

The first experiment was aimed to investigate visual impressions induced by facial skin tone. The visual impressions were measured in terms of bipolar scales including active/passive, vibrant/dull, healthy/unhealthy, extraordinary/common, cute/not cute, sexy/not sexy, natural/unnatural, sensible/insensible, beautiful/ugly, young/old, delicate/strong, innocent/worldly and like/dislike. These scales were selected on the basis of a questionnaire survey conducted before the main experiment. A total of 75 skin tones were tested using the face images, assessed by 35 observers with normal colour vision. The face images were presented on a 27-inch liquid crystal display (LCD) with a display luminance of 79 cd/m_2, situated in a darkened room. The experimental results show that the lightness of skin tone had little effect on all scales studied. There was a strong effect of hue on the impression of skin tone for all scales. The chroma of skin tone had significant effects only on “beautiful/ugly” and “sexy/not sexy”. Regarding whether there was any gender difference in the observer responses, male and female observers were found to agree with each other for “cute/not cute”, “sexy/not sexy” and “natural/unnatural”.

The second experiment used face images with 3 skin tones and 45 lip colours, resulting in 135 combinations, as the stimuli, each assessed by 30 observers with normal colour vision. The experimental results show that observers’ impression was significantly affected in terms of “beautiful/

ugly", "extraordinary/common", "vibrant/dull" and "delicate/strong". The lightness, chroma, and hue of lip colours were all found to have significant effects on all scales. Male and female observers were found to agree with each other in terms of "harmonious/disharmonious" while they had different responses in "delicate/strong ".

PS1-22

International Comparison of Uses of Color for Pictograms

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ABSTRACT

Pictogram is a square including representative figure which indicates function or purpose of the facility. ISO7001:2007 and JIS Z8210:2002 standardize various pictograms, and new pictograms are being proposed as needed. These pictograms are used in countries with different languages spoken, so although with different degrees of recognition, they are able to make people understand the space intuitively. They are useful in constructing urban building space becoming more and more international. "Safety Colors" of JIS Z9103 are applied to pictograms for fire preventive equipment and evacuation signs, but other pictograms tend to have white background and black foreground internationally. On the other hand, in Japan, pictograms for toilets have distinct tendency of colors (blue for men, red for women). There are various ways to use colors for pictograms.

Our study therefore conducts comparative survey on colors of pictograms in order to grasp the possibilities for pictograms to be attached to certain images pertaining colors, and to establish basic data for designing signs. In 2008 and 2009, we surveyed on colors of pictograms at international airport terminals, major railway stations, city halls, museum/historical buildings, major commercial centers, hotels, and parks in 14 cities in 7 countries. One spot of one facility is the subject, and if there is a pictogram, its background and foreground colors are measured on the spot by visual photometry using a color chart based on the PCCS color coordinate system.

The results of Toilet-Pictogram (at 31 women's toilets and 25 men's toilets) indicates tendency that European countries use achromatic colors without gender difference, and China uses multiple colors. We also surveyed 33 unisex toilets in 5 countries. 27 toilets use pictograms including both male and female symbols, and 6 toilets use only the letters "WC". All of them use one same color, without differentiating genders. In Japan, unisex toilets usually have pictogram with two different colors for each symbol. But this survey results show colors are not tied to symbol's meaning internationally.

Evacuation signs' coloring is regulated by ISO and JIS. Among 74 Pictograms in this survey, 88% are with white foreground and colored background in 3G5.5/11.0, whether it is at an exit or in a passage. In Japan, the color combination of the passage evacuation signs is reversed. Same arrangement is seen in 6 cases in China (Taipei and Hong Kong). Therefore it is suggesting that the color combination difference in passage evacuation signs is only regional around Japan.

Gender image attached to particular color for pictogram is only seen in Japan, not elsewhere. In order to design signs in international perspectives, it is important to consider differences of culture, religion gender as well as color image. On the other hand, as our study shows there is some common tendency of color use. Finally, our survey finds some pictograms not honoring ISO color regulation. In order to ascertain that pictogram functions as common language, and to let them function for safety, further action will be called for to eliminate such case.

PS1-23

The Influence of Colour on the Perception of Cartographic Visualizations

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ABSTRACT

This contribution aims to overview the use and influence of color on the perception of cartographic visualisations. Cartographic products are generally a very powerful tool for communicating a visual and spatial related information. At the same time, color is generally considered as the most important graphic variable for expressing the spatial information with cartographic visualizations. With a help of appropriate use of colors, the content of each map can be significantly accentuated and the legibility and comprehensibility of the map could rapidly increase. Equally, the use of inappropriate colors and their mutual combinations could significantly decrease the perception of the visualized information. Color is used for depicting most elements and symbols within a map and therefore helps to communicate the cartographic information and also increases the legibility of the map and its aesthetic quality. This is because colors and their mutual contrasts influence not only the aesthetics of a map and an emotional response but also the usability aspects. Colors evoke certain emotions in a user that can significantly affect the effectiveness and efficiency of the user's decision making and well chosen color properties for various cartographic symbols in a map allow the user to effectively distinguish a map's content.

The appropriate use of colors is very important factor mostly in fields as a crisis management where the used cartographic visualisations help to effectively transfer the required information. The well chosen color scheme with corresponding contrasts is the right way to depict the overall character of the area or phenomenon. The decisions based on unclear cartographic visualisations could lead to various misunderstandings, which could eventually cause weighty losses. In general, cartographic products for crisis management are being employed by users who need to obtain required information as quickly as possible, with an appropriate level of accuracy. Through the employment of adequate color contrasts optimum differentiation between the figure (the most important) and the background (less relevant) information can be achieved. This effect helps to increase significantly the efficiency and effectiveness of perception of required information, which has a strong impact on the level of the general usability of a map.

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PS1-24

Evaluation of Colour Appearances Displaying on Smartphones

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ABSTRACT

Despite of the limited size and capacity of a mobile phone, the urge to apply it to meet quotidian needs has never been unencumbered due to its appealing appearance, versatility, and readiness, such as viewing/taking pictures and shopping online. While a smartphone can act as a mini-computer, it does not always offer the same functionality as a desktop computer does. For example, the RGB values on a smartphone normally cannot be modified nor can white balance be checked. As a result, performing online shopping using a mobile phone can be tricky, especially when buying colour sensitive items. Therefore, this research takes an initiative to investigate the variations of colours for a number of smartphones while making an effort to predict their colour appearance using CIECAM02, benefiting both phone users and makers. The paper studies models of Apple iPhone5, LG Nexus 4, Samsung, and Huawei, by capitalising on comparisons with a CRT colour monitor that has been calibrated under the illuminant of D65, to be in keeping with the usual way of viewing online colours.

Methods: thirty test colours are randomly selected and presented on both CRT monitors and smart phones. Each test colour is posited at a centre against a grey background (with 20% of luminance of reference white) and is adjacent to a reference white, reference colourfulness and a number of surrounding colours. Psychophysical experiments are then conducted by 10 subjects using the technique of magnitude estimation, together with the colour measurement carried out using the colour meter of CS-100A on both CRT and phones.

Results: In terms of the measurement on each phone, encouragingly, the variations among the same kind of phones are insignificant with less than 3 DE CIELAB. In addition, when comparing with subjects' hue estimations, all phones and the CRT monitor appear to have similar hue values, indicating that the hue values have been well reserved on those phones. However, when it is viewed on a phone, a colour appears to show at variance with its lightness and colourfulness by appearing much more colourful and brighter. Furthermore, the correlation coefficient (r) for CIELUV L* are 0.963, 0.959, 0.960, and 0.940 for iPhone, LG Nexus4, HuaWei and SamSung respectively, and are 0.890, 0.876, 0.761, and 0.764 respectively for CIELUV C* when comparing with the counterparts on the CRT monitor. Therefore, the iPhone tends to be the best with fewer scatterings. To predict a colour on a mobile phone using CIECAM02, the predictions rest on a number of environmental parameters settings, e.g., f = 0.9, c = 0.59, and nc = 0.90, which gives closer results with less scattering. Consequently, for an image of truthful colour to be displayed using a mobile phone, the forward and reverse model of CIECAM02 will have to be applied. Specifically, for iPhone5, half of the lightness and colourfulness predicted by CIECAM02 need to be factored into. Further studies will take more number of phones into consideration.

PS1-25

Colour Management for High Dynamic Range Imaging

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ABSTRACT

This paper will explore techniques of capturing images of scenes that have a higher subject luminance range than the dynamic range of the image sensor. This can be achieved by multiple exposures of the same scene and then make a composite image that records the full tonal range of the scene. Alternatively, a sensor with an extended dynamic range capture capability could also be used to capture the full tonal range of the scene.

High dynamic range (HDR) composite images can be used to create photo-realistic and hyper-real images. Parameters including contrast ratios and tone mapping functions are used to control HDR image processing. However, the dynamic range of real world scenes is highly variable and digital cameras need to be characterised for different scenes. This research aims to investigate and compare colour management processes and image processing between standard and HDR image capture. It will also assess the advantages of HDR images by revealing perceived differences and to ascertain the boundaries where HDR imaging becomes a significantly advantageous process to use.

The proposed research method initially sets up an optimised camera characterisation using standard capture of a scene in controlled lighting conditions. The subject luminance range will then be extended beyond the dynamic range of the camera sensor through experimentation by controlling illumination and the subject using calibrated digital colour test charts. HDR capture techniques will then be employed to create composite images, from which colour reproduction can be assessed in comparison with the original scene. This process will be used for a range of types of scenes using natural and artificial light sources. The aim is to identify which types of scene is best served by HDR imaging, and ascertain what are the benefits to people looking at HDR images to help improve their viewing of images of different subject matter.

PS1-26

Development of a Wide-Gamut Digital Image Set

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ABSTRACT

A great many imaging devices are consistent with the sRGB colour space. However, wide-gamut display devices exist that conform to colour spaces that have wider gamuts such as Adobe (1998) RGB. This colour space encompasses about 50% of the colours in CIELAB and improves on

the gamut of sRGB in the green-cyan colours in [particular but also in the yellow region. There is a shortage of standard image sets that contain colours that are outside of the sRGB gamut. Such images could be useful, for example, for testing various performance metrics in wide-gamut display systems. The purpose of this work is to develop a wide-gamut image set and make it widely available on the internet for the imaging community.

Three digital SLR cameras were used to capture a large number of images that contained saturated colours. The colour space of the cameras was set to Adobe RGB and the file format was set to record raw. The images were transferred to Adobe Photoshop and converted to 48-bit TIFF images in the Adobe colour space. MATLAB was used to process the images and to ascertain the proportion of pixels that were outside of the sRGB gamut in each case. Image that contained less than 15% of pixels that were outside of the sRGB gamut were rejected. Images were also rejected if they were blurred or if the out-of-gamut pixels were not associated with particular objects in the scene. Images have been made available on a website – in both raw and tiff formats – and are categorised according to their colour and also according to the description of the objects for which the pixels are out of gamut. Example, object classifications include textiles, jewellery, arts, plants, foodstuffs and electronics. A total of 100 wide-gamut images were selected and have been made available to the community.

PS1-27

Construction of Display Profiles Using Simplicial Maps and Application to Color Reproduction of Displays

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ABSTRACT

Due to rapid progress of information technology, our opportunities to observe color images on various displays are increasing too. Recently usage of both large scale panels and diminutive displays of smart phones or wearable terminals have also widely spread into our daily life.

With color images, we perform various things such as taking photos, seeing, editing, and more through various displays. But since each display has its own color reproduction characteristic and color gamut, when we input the same color data to different displays, their outputs will not be the same. In the cases of buying clothes on Internet or exchanging digital photos via personal computer, such differences on different displays could cause different impression which may mislead our judgment. Furthermore, in remote medical treatments, these differences of color could result in wrong diagnoses.

To achieve a uniform color reproduction between different devices, a framework proposed by ICC using device profiles has been widely used. This scheme uses a profile for every device to describe their unique characteristics in color representation or reproduction. Currently, most color devices are furnished with a profile by the device manufactures which are used in the ICC color reproduction scheme. Certain commercial softwares of profile making are also available.

However, certain problems remained for this approach. For examples, it cannot compensate the variations between individual devices even by the same manufactures, or changes due to device aging. Moreover, the profile format suggested by ICC describes device characteristics in a 3D color space by a product of three 1D (usually monotonous) functions. This format is a very rough approximation of a 3D characteristic or a nonlinear map of a common device in the color space. It may have been used for fast implementation but have no enough representation capability in high precision color reproduction.

In this paper, we present a new approach for color reproduction of displays. In particular, an algorithm to built profiles for monitors is proposed based on simplicial maps. The proposed method first measures the color reproduction characteristic of the device for a list of target colors. Then the convex coordinates in a simplex is calculated from neighborhood points for input and output on PC displays. In this way, a simplicial map is obtained which can be used as the profile of the device. In fact, applying the inverse map of this simplicial map to input images will compensate the device characteristic to obtain a faithful color reproduction.

We investigated the following three implementations of the proposed method with different computational costs: 2D maps of the chromaticity plane, 3D maps of the color space which compensate chromaticity and brightness simultaneously, and (2+1)D maps which compensate chromaticity and

brightness separately. The (2+1)D version shown to be a reasonable trade-off between performance and cost.

Finally, the proposed method and commercial profile makers are compared in terms of quantitative color difference between input and output colors. Besides, natural images are also used as input data for subjective comparison. Both experiments confirmed effectiveness of the proposed method.

PS1-28

"Psycolorsynthesis": An Introduction of 10-Color Communication Method

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Office Color Palette

ABSTRACT

"Psycolorsynthesis" is a newly developed concept derived from psychosynthesis. While harmonizing one's plural selves to attain integration of the personality is what Assagioli (1965) calls psychosynthesis, this paper shows that colors can play a critical role to attain this integration. 10-color communication method is introduced to demonstrate that colors enhance the awareness of self as well as others' understandings. And this awareness brings about personality integration. The method applies colors as an effective medium for people to express themselves regardless of their social status and contexts. The method calls for a workshop with a group of 8 to 12 people, and let each of them use a set of color cards (normally about 200 colors). It consists of two modules: communication with self by making a color identification data (ID) arranged from 10 selected favorite colors and communication with others by giving 2 colors to other participants as a gift. Data collected from more than 300 workshop participants identify that approximately 80% of them show clear correlations between 10 self-selected favorite colors and colors received from others as a gift. In addition, workshop observation suggests that communication with a medium of colors clearly enhance relaxed interactions among participants and result in becoming aware of self and others. 10-color communication method demonstrates that the power of colors can overcome risks, worries, and fears that people have deal with when they attempt to share their inner-colors. When colors applied to people as their representations, each color-ID (representing each person) is unique and distinctive, for which nobody can say better or worse compared with others' color-IDs (representing other persons). This communication method can effectively be applied to improve the practices of social activities such as recruiting and counseling.

PS1-29

Perceptually Inspired Gamut Mapping between Any Gamuts with Any Intersection

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ABSTRACT

Gamut mapping transforms the color of an input image to within the range of a target device. A huge amount of research has been devoted to two subproblems that arise from this general one: gamut reduction and gamut extension. Gamut reduction algorithms [1,2,3] convert the input image to a new gamut that fits inside the one of the image , i.e. the gamuts' intersection is equal to the target gamut, while gamut extension algorithms [4] convert the input image to a gamut that embodies the original image gamut, i.e. the gamuts' intersection is equal to the source gamut. In contrast to the two aforementioned cases, very little attention has been paid to the most general problem, where the intersection of source and target gamut is not equal to one of the two gamuts. In this paper we address the general problem of gamut mapping between any two gamuts presenting any possible intersection. To deal with this problem we unify the gamut extension and gamut redution algorithms presented in Zamir –et al- [5], which are based in the perceptually inspired variational framework of Bertalmío –et

al- [6] that presents three compiting terms; an attachment to the original data, a term for not-modifying the per-channel image mean (i.e. not modifying the white point), and a contrast enhancement term. In this paper we show that by defining a smooth transition on the contrast enhancement parameter over the chromaticity diagram we can simultaneously reduce the input gamut in some chromatic areas while increasing it in others without introducing neither color artifacts nor halos. Our method could be useful in several different applications such as cinema postproduction (where different image looks may be obtained), color transfer, or semantic enhancement.

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PS1-30

Color Correction Operation for 3D Scanning Models

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ABSTRACT

Nowadays, 3D scanner is capable of acquiring realistic 3D objects. The correction for the color information of 3D scanned models, however, is still a challenging topic. Since the formation of "color" highly depends on lighting conditions, material properties and geometrical shapes. To improve the color appearance of the 3D objects, we develop a practice solution for color calibration, particularly for 3D scanned models. We initially fabricate a color 3D scanner based on a laser and a stereo camera, and then, we carry out the software for calculating 3D models. Likewise, this 3D scanner consists of a turntable with motor control unit, for rotating a 3D object to specific positions, and several LED light bulbs. All the signal of construction is delivered by Arduino unit. During the 3D scanning process, eight range data of the 3D object are obtained and integrated into one digital 3D model. The color images, which are pre-calibrated, are again cast on this 3D model by considering geometrical shapes.

In color correction operation, first, we put a white board on the turntable of our 3D scanner, and took several pictures. Then, we made the white board in all pictures uniform. Since LED may irradiate in a non-uniform distribution. Second, color calibration for 3D scanner is performed. The 24-color board with ColorChecker is again put on the same position. Similarly, the ColorChecker images are converted as uniform according to the first treatment. Then, all images with uniform brightness are again regressed by using a polynomial equation. Since the reference tristimulus values XYZ, of the color checker are the ground truths, the measured tristimulus values of color checker emitted by the utilized white LED are finally much close to the reference values after the least square estimation.

The initial experimental result in 3D scanner color correction stage shows the average color difference values ΔE^*_{94} for non-color correction is 25.3 and those for color corrections using by the 1, 2, 3 order regression equations are 11.2, 6.4, 4.6 respectively (See Figure 2). Finally, color correction for compensating color shifting due to the different depth positions of a scanned object will be executed. The final results will be reported in the full paper.

PS1-31

Correcting for Induction Phenomena on Displays of Different Size

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ABSTRACT

In visual perception, induction designates the effect by which the lightness and chroma of an stimulus are affected by its surroundings. When the perception of an object shifts towards that of its surround the phenomenon is called assimilation; in the opposite case, when the perception of an object moves away from that of its neighborhood, we talk about contrast. Visual induction manifests itself both in achromatic and chromatic form, and the ocurrence of assimilation or contrast is determined by the spatial frequency of the stimulus (Helson 1963, Fach and Sharpe 1986), with assimilation being associated to large spatial frequencies and contrast to lower ones.

A common observer looks at images on displays of vastly different sizes, from cinema screens to mobile phones, and in general the usual viewing distance is not proportional to screen dimensions. For instance, a comfortable distance to view a 50 inch TV screen may be 10 feet, or 120", whereas for a mobile phone screen of 5 inches the usual viewing distance is around 15" (Heinonen 2013). This difference in the ratio of screen size over viewing distance implies a different angle of view for each screen, and therefore a change in the spatial frequency of the image content when viewed on different displays. As a consequence, the visual induction phenomena will also change from one screen to another: the same image may show significant assimilation effects when displayed on a screen, and less assimilation or even contrast when displayed on another.

In this work we introduce a model for visual induction based on efficient coding and which elaborates on a previous approach (Bertalmío 2014). We show that this new model is able to qualitatively replicate psychophysical data on visual induction, and we propose a method by which an image can be pre-processed in a screen-size dependent way so that its perception, in terms of visual induction (i.e. ignoring the color capabilities of the displays), may remain constant across displays of different dimensions.

PS1-32

KANSEI Evaluation of Color Images Presented in Different Blue Primary Displays

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ABSTRACT

Recently, Rec.ITU-R BT.2020 has been published, and the new era for a super-wide color gamut has been started. It is generally accepted that the wider the color gamut, the better the color reproduction performance of the display. In the comparison of the color gamut, percentage of the coverage for the chromaticity coordinates of real objects is often used. However, few have been reported on the comparison of color gamut from image preference or naturalness point of view. Among the three primaries, blue primary is considered to affect most on the color tone or color shade. Therefore, to investigate the best blue primary for color display from KANSEI-evaluation point of view, evaluation experiment was carried out using four different blue primaries of 430nm, 450nm, 470nm, and 480nm.

Before the experiment, test image selection was carried out. Color distributions of more than 2600 images were analyzed based on our categorical color database, and 15 color images are selected as the test images from them. They are representatives of red, pink, orange, yellow, green, blue, purple, red-green, red-blue, yellow-green, yellow-blue, blue-green, skin, multi-colors, and monochromatic

groups.

In the experiment, the test image was projected by the 2 projectors, one was for blue signal (B projector) and the other one was for the red and green signals (R&G projector). Interference filters of lp = 430nm, 450nm, 470nm, and 480nm were inserted in front of the projection lens of the B projector to achieve different blue primaries. Images from the two projectors were carefully superimposed. White balance of different blue primary conditions was set nearly the same by adjusting the gain control and inserting appropriate ND filters in front of the B and R&G projectors.

Evaluation experiments were carried out with 2 luminance levels of 60 cd/m^2 for 430nm, 450nm, 470nm, and 480nm, and 170 cd/m^2 for 450nm, 470nm, and 480nm. Test images with different blue primaries were randomly presented. The semantic differential method was used to quantify subjective evaluations of images using 14 adjective pairs. Eleven observers participated the experiment.

Results of the 4 blue primaries comparison, 430nm, 450nm, and 470nm blue primaries showed similar performance except for the skin color image for which evaluation score of 430nm became lower than others. 480nm blue primary showed the worst performance for almost all test images and adjective pairs. Results of the 3 blue primaries comparison, 470nm showed the best performance, while 480nm showed the worst in this case, too. Generally, marked difference of evaluation was found in the bluish, greenish, and purple images, while no difference was observed in the red and orange images. Results are compared with the chromaticity distributions of test images in different blue primary conditions. Certain area of bluish region in the chromaticity diagram or color space is critical for KANSEI evaluation of bluish, greenish, and purple color images.

PS1-33

New Proposal for Advanced Measurement Technology for Image Clarity

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ABSTRACT

Evaluation of object surface structure has traditionally involved the assessment of properties known as Gloss and Haze. More recently the property of surfaces known as Image Clarity has gained major importance because such property can vary while the traditional properties remain constant, and vice-versa. The optical phenomenon exists in both reflection and in transmission mode. We have evolved the design of instruments used to measure the phenomenon by using a narrow, diffraction limited optical beam and a CCD array as a detector. Results are obtained by analysis of the surface optical transfer function using Fast Fourier Transforms for computational speed.

This affords several improvements over previous technology. Analytic features additional to those presented previously are available. This allows the assessment of new appearance methods and metrics to be assessed in addition to those traditional modalities; such as gloss, haze, orange-peel, surface texture and image clarity. Further, the measurement time is more rapid then bench top instruments allowing for near real-time measurement as well as continuous monitoring of a moving plastic sheet or other processes in need of continuous examination. Both short and long wave surface phenomena are assessed with equal accuracy. The rapidity of measurements affords a manufacturer the opportunity to assess the impact on surface quality of his product by parameters in the manufacturing process, and thereby control such parameters.

Correlation obtained with traditional assessments, such as gloss and haze, and the correlation with visual assessments add to previous designs. Both precision and accuracy are improved by the present design. The fact that the present design is smaller and lighter than previous ones provides the very important property of portability to the instrument. The device is all solid-state.

End users will come from processes that require control of surface reflectance, or transmittance, maintenance of quality, either real or perceived. These will be industries and applications, such as; automotive enamels, coated surfaces, displays, films, glasses, material smoothness, paper processing, paper smoothness, painted panels, photographic hard reproduction media photographs, plated surfaces, plastics, polished surfaces, printed materials, surface texture and other industries where quality of surface structure or the quality aspects of components appearance is important.

PS1-34

Analysis of Color Appearance of Metallic Colors and Pearlescent Colors Using Multi-angle Spectrophotometer

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ABSTRACT

During the last few decades, there has been a rapid growth of special-effect performance due to the development of effect inks and post-processing technologies. The special effects include metallic and pearlescent coating technologies, generated by using metallic and pearlescent inks. Because the appearances on the material surfaces could vary with the direction of illumination and viewing, the multi-angle spectrophotometer is used in the quantification of angle-dependent color appearances in this study.

The purpose of this study is to examine the relationship among different ink, color appearance, texture change, illumination type and viewing angle conditions. In this study, color samples of pearlescent and metallic color printed with different inks are measured using multi-angle spectrophotometer under different illuminating/ viewing geometries. Under directional illumination, the color appearance including CIE colorimetric values and the other appearance parameters including sparkle grade are assessed at given angles and from the normal direction. Under diffused illumination, the appearance parameter of graininess is evaluated from the normal direction. For this experiment, total eight metallic, eight pearlescent and eight solid color samples were prepared. Colors of samples included red, orange, yellow, green, blue, violet, light grey and dark grey. Also, considering gloss as a specific appearance attribute, two degrees of gloss in the samples so called semi-matte and gloss samples were prepared.

The measurement results showed that lightness of samples becomes larger with receiving angle accordingly up to specular direction. The lightness change is dramatic in pearlescent and metallic colors. In case of pearlescent colors, chroma change with receiving angle is significant and become smaller as receiving angle become larger (see Figure 1). On the other hand, the metallic flakes make the samples sparkle and look somewhat grainy. The solid inks have no sparkle effect except the color effects. In addition, the main impact of the gloss surface was the lightness value close to the aspecular angle of -15°, 15°. The lightness value of the semi-matte surface was higher than the gloss one, and the chroma value of the semi-matte surface was lower than the gloss one (see Figure 2). The complete results will be reported in the full paper.

PS1-35

HDR imaging – Automatic Exposure Time Estimation A novel approach

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ABSTRACT

Digital imaging of common scenes can be a very challenging task if the scene radiances present a high dynamic range (HDR). HDR imaging techniques are applied to overcome this issue. The most popular technique, which is valid to be used with any consumer or professional digital camera, is based in the combination of differently exposed low dynamic range (LDR) images. However there is a lack of a robust method for determining either the amount of LDR pictures needed, or their exposure time settings, without any prior knowledge of scene content. We propose a novel method for estimating the set of exposure times (bracketing set) needed to capture the full dynamic range of a scene with HDR content. The proposed method is adaptive to scene content because the bracketing sets adapt to cover the dynamic range of each singular scene being captured. It is also adaptive to any camera response

and camera configuration, because we only need to calculate the camera response function (CRF) of our camera in the capturing mode or configuration it is working on (raw, jpeg, etc). Our method works on-line, since the exposure times are estimated as the capturing process is ongoing. Therefore, it requires no a-priori information about scene content or radiance values present on the scene. The resulting bracketing sets are minimal for the scene being captured, as contiguous exposure times have certain overlap to avoid gaps in the dynamic range which are not properly captured, but this overlap is minimum. The user can set a tolerance for the maximum percentage of pixel population that is underexposed or saturated. This method is based in the use of the CRF, which is needed for building the HDR radiance map by stitching together several, differently exposed, LDR images of the scene.

The use of HDR imaging techniques, converts our digital camera in a tool for measuring the relative radiance outgoing from each point of the scene, and for each color channel. We can use this method separately for each color channel, in case our imaging system has independent exposure settings for different channels. This method can thus also be used for multispectral imaging systems. We have compared our method with the most complete and efficient HDR bracketing set estimation algorithm developed so far to our knowledge (Barakat et al. 2008). Preliminary results suggest that our proposed method equals or outperforms the previously developed best approach, with smaller bracketing sets found (lower number of shots and shorter exposure times), asserting the advantage of being adaptive to scene content for exposure time estimation.

PS1-36

Real-time Green Visibility Ratio Measurement

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ABSTRACT

Green visibility ratio is one of the important indices for urban environment assessment. The green visibility ratio is defined as the ratio of vegetation green in an image. The green area is usually detected manually. There is a product for automatic green visibility ratio measurement, which measure the green visibility ratio using color information only. Some artificial green objects, such as advertisement boards or signboards, often exist in the urban scene. Therefore, the discrimination of the vegetation green from other green objects is required for automatic green visibility ratio measurement.

This paper presents a real-time green visibility ratio measurement method by detecting vegetation green from images captured by a USB camera. This method is based on color and texture analysis. Artificial green areas have planar surfaces in general, while natural vegetation green areas have three-dimensional shapes by leaves. Therefore, artificial green areas have few color values or moderate color variation, while the vegetation green area includes large brightness changes caused by the shade of leaves. Our method defines the vegetation green area as the green color area with brightness fluctuations.

The proposed method detects the brightness variations by using the Sobel edge detection filters. The detection of the vegetation green area is done by the following steps: 1) image capture by a USB camera; 2) green color detection from the captured image by the ratio of the R and G values to the sum of R, G and B values; 3) detection of edges as brightness changes by Sobel filters; 4) detection and binarization of vegetation green pixels by AND operation between green color pixels and large edge pixels; 6) recursive dilation and erosion operation for closing holes in the vegetation green area; 7) calculation of the ratio of the number of pixels in the vegetation area to that of all the pixels in the image; and 8) display of the green visibility ratio on the captured image.

We conducted experiments with images including trees and artificial green objects. The experimental results show correctly detected tree areas and good feasibility of the proposed method.

PS1-37

Evaluation of 20 p/d-safe Colors Used in Image Color Reduction Method for Color Deficient Observers

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ABSTRACT

This manuscript describes an image enhancement method for color-defective observers, named image color reduction method, and presents an evaluation of this method; this evaluation is based on the analysis of chromaticity distribution.

Sakamoto [1] proposed a color reduction method using a color palette, especially designed for protan and deutan defects (commonly known as red-green color blindness). Sakamoto's method involves replacing confusing colors with protan and deutan-safe (p/d-safe) colors. These p/d-safe colors are preliminarily selected and they form the p/d-safe color palette. The image enhancement processing for color-defective observers is performed on the basis of the p/d-safe color palette that is implemented as a look-up table.

In this study, chromaticity distribution of composed colors in the palette is analyzed and evaluated using CIELAB color space and quasi-uniform color space derived theoretically from LMS (the response of the Long, Medium and Short cones of the human eye) color space. The results of the evaluation are described in this paper taking into consideration of visibility for color-defective observers, uniformity of the chromaticity distribution, color category, and color gamut width.

The results of this study suggest that Sakamoto's color reduction method is effective in enhancing image colors for color-defective observers. Further discussion about this method and processing results are expected to be described in the technical report of CIE TC 1-89: Enhancement of Images for Colour Defective Observers. Visual experimental verification of the color reduction method by dichromatic color-defective observers and comparison between the other image enhancement methods for color-defective observers will be subjects of interest for our near-future works.

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PS1-38

Silkscreen Printing on Cotton Fabrics with Soil Colorant

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ABSTRACT

Recently, there is an increasing interest in natural or eco-colorants. Soils are natural colorants that have been used since ancient times before synthetic colorant quickly replace them. In this study 3 types of soil: black-, yellow- and red soils were used as sources of colorants of silkscreen ink for printing on cotton fabrics. Soil colorants were prepared by grinding soil into fine powder, then dissolved with water and left overnight for sedimentation. The supernatant liquid was discarded and the sediment was collected as soil colorant. Soil colorants were mixed with water based silkscreen medium for silkscreen inks. Physical properties of 3 types of silkscreen inks from soil colorants were measured. The result showed that density of silkscreen ink of black soil, red soil and yellow soil colorant were 1.02, 0.53 and 0.75 and the CIE (L*a*b*) values were L* = 47.79, a* = 7.57 b*= 19.54; L* = 72.18, a* = 17.88 b*= 27.55; L* = 72.26, a* = 15.18 b*= 38.91, respectively. Silkscreen inks from soil colorants were printed on cotton fabrics with the resolution of image printed at 30 LPI. The printed cotton fabrics were measured for halftone, dot gain, density, and wash-resistant. The results showed that silkscreen ink printed on cotton fabrics gave good quality line at 1-6 points for every soil colorant. The halftone was 10-50% for red- and yellow soil while black soil halftone was 10-40 percent. Densities of printed cotton fabrics before washing were 1.02, 0.53 and 0.75 for black-, red- and yellow soil, respectively. After washing printed cotton fabrics for three times the results showed

that densities were changed to 0.99, 0.52 and 0.73, respectively. Dot gain of black soil at 10 - 20 percent showed normal dot gain and gave a good printing quality but dot gain more than 60 percent appeared solid ink density. While red- and yellow soil dot gain was 10-40 percent showed normal dot gain and gave a good printing quality but dot gain more than 70 percent showed solid ink density. In addition, quality of printed cotton fabrics not only depends on printing ink but also the worker has to have printing experience.

PS1-39

Estimation of the Environment Illumination Color Using Distribution of Pixels

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ABSTRACT

Color of pixels in images depends on the surface conditions of objects and environment illumination. It is difficult to determine which factor is cause of the changing color of pixels. Therefore, techniques for estimating the illumination color of the imaging environment from an image are determined. This paper proposes a new technique to estimate the illumination color by examining the pixel distribution in a feature space for each characteristic of the surfaces of objects. The method use a log-chromaticity differences(LCD) space that represents the color of each pixel in two-dimensional axes as the differences between the logarithm of R and G(log(R/G)), and B and G(log(B/G)). The method to estimate the color of illuminations is a clustering of the LCD values for each color temperature using support vector machine(SVM).

In this study, the distributions of target pixels corresponded to the surfaces of objects under different illumination conditions are plotted in LCD space. We use the images of cylindrical papers with shading under controlled illumination in dark room as test data for experimentation. The colors of objects are seven colors of white, gray, blue, green, orange, purple and yellow. The Illumination lights are eleven types of daylight from 3500K to 8500K for training data, and 24 types for test data. The target pixels are taken from place of change to the shade from the bright part of the object, avoiding the specular reflection region. The four feature values of log (R/G), log (B/G), angular coordinate in LCD space, and brightness obtained from target pixels are used to perform clustering for each image by SVM.

The results of the verification experiment for test data, the number of the estimated class matched to the correct color temperature class was 21 of 24 illumination conditions, and the rate of correct was 86.5 % . The proposed method estimated the wrong class in three conditions of 3801K, 7616K, and 8136K. The three conditions were classified to the nearby classes of the correct classes.

In this study, the training data obtained from images taking seven objects. It can be expected to improve the illumination estimation accuracy through using combinations of different colors. Moreover, it is necessary a verification under illumination light such as fluorescent lamps and LED lights because neither of the training data and the test data was obtained from images taken in the same environment using the spectral light source device.

PS1-40

A Spectral Reflectance Measurement System for Human Skin by Using Smartphone

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ABSTRACT

This paper describes a method for estimating the spectral reflectance of human skin based on multi-spectral imaging by using a smartphone. A spectral reflectance of human skin is very useful for a health care and beauty in cosmetic fields. By this system, anyone can measure spectral reflectance of

human skin with smartphone and color chart.

First, we develop a multi-spectral camera model of a smartphone for describing a light reflection process of a smartphone camera system. A camera of the smartphone has an automatic exposure and an automatic white balance function. The camera output (RGB) is modeled with spectral reflectance of human skin, spectral distribution of illumination, camera sensitivity and time parameter in the visible wavelength [400–700 nm].

Second, we propose a simplified method for estimating spectral reflectance using a smartphone camera based on the multi-spectral camera model. We assumed that the spectral reflectance of a human skin surface can be described as linear combination of some basis functions. On the assumption that the system conversion matrix from the camera output to spectral reflection is estimated based on statistically analysis of tuple of spectral reflectance and camera outputs (RGB).Generally, smartphone camera has an automatic exposure and an automatic white balance function. The exposure and white balance is fixed correctly with a color chart.

Third, we implement a position detection method for improving accuracy of human face and color chart position calibration. In the results, we can estimate spectral reflectance in arbitrary part of the human face.

Finally, to confirm accuracy of the proposed method, we measured spectral reflectance of human face with a smartphone. The estimation results were compared with direct measurement of spectral reflectance with spectrophotometer. Consequently, it was possible to obtain the estimation results of spectral reflectance of human skin with high precision. The detail of estimation results will be described in the proceedings.

PS1-41

Colour Management for High Quality Reproduction on Uncoated Papers

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ABSTRACT

In recent years, the appeal of uncoated paper has undergone a dramatic image change in the eyes of designers and printers, contributing to the growing demand for uncoated stock. There is a wide range of high quality uncoated papers on the market today, available in many different textures, colors, weights and finishes. Because of their tactile properties and natural surface, uncoated papers create a much stronger impression and lasting value compared to coated papers. On the other side, coated papers have an advantage in the standardized reproduction process and achieve higher quality printing results. The challenge is to ensure that uncoated print results are able to match the performance of color prints on coated papers.

The goal of this research was to establish the consistent and predictable workflow from screen to the print on uncoated paper, taking into account the specific constraints of the substrate and the reproduction process. The substrate is a major factor in determination of the attainable full-tone density and affects the reproducible color contrast, which both have a large impact on overall print quality. The specific restrictions on uncoated paper are determined by a rough surface on which there is always a large dot gain, reduced relative printing contrast compared to a print on coated papers, as well as the reduced gamut of colors that can be reproduced. By implementing color management ICC profiles characterized for specific uncoated printing substrate and by conducting proposed correction methods in the prepress, as well as optimizing the thickness of ink in printing, it is possible to achieve high quality color reproduction.

In the experimental part of this work special test target was designed and printed in offset on three different uncoated papers and one coated paper. The test target was composed of ten types of color strips for instrumental measurements of dot gain, relative printing contrast, raster tonal value, full-tone density, etc. In addition, a photograph for visual assessment of prints was included. To be able to objectively compare the color differences of prints, spectrophotometric measurements of color strips were also made and analyzed.

PS1-42

A Real-Time Multi-spectral CG Rendering Method for Building with Scene Illumination

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ABSTRACT

In the fields of digital archive of buildings, high quality walk-through rendering method is required. To walk around various places with viewing landscape, we develop a rendering method for buildings with scene illumination. The rendering method need to render precise lighting, shading, gross and soft shadow et al. in the real scene illumination. For the realistic rendering, the system needs to calculate illumination distribution characteristics in the scene and light reflection process on an object precisely. Moreover, it is important that the CG rendering system can reproduce scene illumination precisely. By the conventional RGB-based rendering technique, it is difficult to calculate scene illumination precisely. Because multi-spectral information is physical data peculiar to an object, the multi-spectral data is independent of color device such as a camera.

This paper describes a real-time CG rendering method for building with scene illumination data. However, the multi-spectral scene rendering method with high accuracy scene illumination information needs a huge amount of calculation processing time. Therefore, we improve rendering performance of multi-spectral rendering system with omnidirectional illumination data.

First, we develop a scene rendering system with multi-spectral reflection model include multi-spectral omnidirectional illumination data. The illumination data is measured with fish-eye lens and digital camera. The illumination data is generated as multi-spectral omini-directional image.

Second, to reduce the time for rendering processing of scene illumination, we develop a real-time rendering method for implementing to Graphics Processing Unit (GPU). Moreover, we render a building with a rendering method based on Image Based Lighting (IBL). To improve rendering performance, we develop a multi-spectral irradiance map from the multi-spectral omni-directional image for GPU. And also we develop a data compression algorithm for multi-spectral data for improving resolution and performance.

Finally, to confirm validity of the proposed method, Nagano university campus is rendered by proposed method. And also, we compared CG reproduced image to the real scene. The rendering and experimental results will be described in AIC proceedings.

PS1-43

Color Mapping between a Pair of Similar Facial Images with and without Applying Cosmetics

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ABSTRACT

Computer software is developed to perform color mapping between a pair of similar facial images before and after applying cosmetics in this study. An image-based color palette will be a better choice to achieve high image quality for displays [1]. However, it is difficult to analyze facial color differences between a pair of similar facial images of the same person shot two times by a digital camera, because the facial looks in a person before and after applying makeup could slightly change.

The affine transformation [2] is utilized to match a pair of facial image outlines before and after applying cosmetics. The flow of facial color mapping is demonstrated in Figure 1. It mainly consists of the following parts of triangulation, image morphing and color different calculation.

The first step is triangulation. By choosing several feature points (such as corners of eye and lip, cusps of nose etc.) in the pair of facial images by optical mouse clicking respectively. Then triangulation can be performed in the pairs of facial images. Subsequently, we can use image morphing technology based on affine transformation to match the outline of the sense organs in facial image before applying cosmetics to the one after applying cosmetics.

The concept of affine transformation is as following. When a triangle T_1 has 3 vertices V_1, V_2, V_3 and the point V is in the T_1, it can be expressed by Equation 1. Therefore, in the sane way, the coefficients (C_1, C_2, C_3) can be expressed by another triangle T_2 which vertices are W_1, W_2, W_3 can also satisfy Equation 2. So the point W inside the triangle T_2 can be calculated by the coefficients (C_1, C_2, C_3), as expressed by Equation 2.

$$V=C_1V_1+C_2V_2+C_3V_3$$
$$C_1+C_2+C_3=1$$
$$C_1,C_2,C_3>0 \quad (1)$$
$$W=C_1W_1+C_2W_2+C_3W_3 \quad (2)$$

After image morphing finished, the 8-RGB values of each pixel in the images that are no cosmetics and applied cosmetics, are converted to XYZ values based on sRGB encoding, respectively. Then the corresponding L*a*b* values are also calculated. Finally, the facial color difference map between them is generated by CIE color different ΔE^*_{94} . The final results will be reported in the full paper.

Reference

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PS1-44

The Consistent Color Appearance Based on the Display-referred

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ABSTRACT

In recent years, printing for applications such as advertising and presentations are working to improve the quality of such to reduce the colour variation, which includes the use of colour standards such as 'Japan Color' standard based on ISO12647-2, and the certification body for their operational standards are utilizing.

However, for reasons that determined by the colour difference between the target colour of colour standard and each output colour, the certification has been a problem, can not be fully utilized the colour reproduction capability of the wide colour gamut the printer can not be applied further to a narrow gamut printer. Furthermore, when performing advertising through multi-media with the colour gamut of different reproduction systems such as signage displays or inkjet or offset printing, designer or prepress process is in colour adjustment of each colour reproduction consistently or to look for similar colours.

I'd like to report the results of hypothesis testing that using the most encompassing display reference by assuming the printer with a variety of colour gamut, 'consistent colour appearance' including the reproduction color and tone reproduction, whether can be achieved by development by subjective evaluation approach.

Thus, the multi-color ink-jet with a wide colour gamut to the newsprint with a narrow colour gamut, 'consistent colour appearance' can be realized, thereby enhancing the value of future digital printing by lead to automation.

PS1-45

The Study of Museum Lighting: The Optimum Lighting and Colour Environment - the Proposal for the Colour Quality Index -

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ABSTRACT

Background

The lighting environment of a museum is carefully controlled not to give any damage against deterioration of artworks. In case of the exhibition of Japanese paintings for example, the illuminance level is regulated to constrain at low, under 50 lx in case of the most severe circumstance not to give color fade damage as less as possible.

However, at the view point of appreciation of artworks at a museum, low illuminance means the decrease of inherent color appearance of the artworks because the artworks will lose brightness and colorfulness at low illuminance.

The present ISO/CIE standard for museum lighting recommends that Color Rendering Index (CRI) is over *Ra*80. The lighting environment of a museum is carefully controlled not to give any damage against deterioration of artworks.

Objective

The purpose of this study is to clarify colour rendering properties at low illuminance and also to try to develope the new calculating method to evaluate the colour rendering values taking into consideration of illuminance. We defined "color quality index" called Rx and Rxi to evaluate the new color rendering properties expressing illuminance-effects and hue-effects.

Method

The experiments were performed by a haploscopic viewing method. The observers evaluated subjectively colour feelings, for example dirty-beautiful, darker-brighter, active-passive, of the color samples of the test side compared with colour feelings of those of the reference side by Semantic Differential method (seven categorized scale). The reference light sources were the fluorescent lamps for museum lighting (FL-EDL: *Ra*96, 3060K). The test light sources were the tri-band LED lamps (LED-RGB: *Ra*19, 3050K and the conventional LED lamps (LED-BY: *Ra*96, 3060K). Illuminance levels was set 700 lx, and 10 lx. Various colour samples (ex. the pictures changed of hue) were used in the experiment.

Result

The result showed that subjective colour feelings of the samples including the two colour pairs, the multi colors and the pictures were influenced by illuminance as well as especially by red colour in the samples. Furthermore, it was suggested that the current CIE/JIS Ra or Ri could not explain the subjective impression of the samples illuminated by narrow band mixed-LED lamps such as LED-RGB under low illuminance. We defined "color quality index" called Rx and Rxi to evaluate the new color rendering properties expressing illuminance-effects and hue-effects. It was confirmed that the new index Rx and Rxi correlated practically the subjective results.

PS1-46

Developing Test Targets for Color Management of Full Color Three-dimensional Printing

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ABSTRACT

In traditional two-dimensional (2D) printing, color target is applied to estimate the color performance and make color management work. If we apply the same method to three-dimensional (3D) printing, some problems will be encountered. For example, 3D printing can produce 3D objects with curved surfaces, which have various surface normals towards different directions. Between different surface directions, color differences are noticeable in an inkjet-based 3D printer and it is caused by layer structures of ink and powder. Because of the different characteristics and requirements from the traditional 2D printing, it is necessary to develop new targets for 3D printing.

In this research, several targets with different shapes and measurement methods are designed. One of the targets is designed to estimate color performance of surfaces in 26 directions. The target is combined with 13 pieces in different surface directions, like a puzzle, and each piece has two sides with several color patches on it. The biggest piece, which is printed on top and bottom, has 225 color patches for general color management. The other pieces have 4 or 14 color patches and can represent

the color differences in various surface normals. Each piece has a unique shape to avoid mistakes in combining. The target can be measured by X-Rite i1 Publish after combined 26 pieces in a correct position. Another target is designed as a TC 2.83 RGB test chart, which arranged 283 color patches with C5 size and can be generated in only one page by i1Profiler, the software for generating ICC profiles by X-Rite i1 spectrometer. With the ICC profile generated by i1Profiler, the work of color management can be completed rapidly and simply. The other target has 729 color patches (9-level RGB) with small area (10x10 cm), which is material-saving and can be measured by a calibrated camera. Taking a photo of the target and ColorChecker in a viewing booth simultaneously, the RGB values in particular light source can be read and applied to color management.

The influence of post-processing in color performance is also concerned in the research. The effects of several methods, including coating with cyanoacrylate, salt-water, wax, or unprocessed are compared. It was found that color gamut changes along with different post-processing method. Establishing different processes for each post-processing way is important to make color management well for 3D printing.

PS1-47

The Effect of Training Set on Camera Characterization

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ABSTRACT

It is well known that the performance of the camera characterization model is strongly affected by the training set used to extract the model parameters. In this study, the effect of color gamut size of a training set on the camera characterization model performance is investigated.

As training sets, 'Patch set' and 'Monitor set' were prepared. For 'Patch set', 96 color patches in Gretagmacbeth Colorchecker-SG chart were shown in the viewing booth illuminated with D65 simulator and each color was measured with spectroradiometer and also with the camera. The illuminance in the center of viewing booth was 1090 lux and luminance of reference white was 278.22 cd/m2. The chromaticities of the color patches were mostly distributed within the range of sRGB gamut. In the case of 'Monitor set', 84 colors were shown on the wide-gamut LCD monitor in a dark room covering around Adobe RGB color gamut. The luminance of the peak white was 262.74 cd/m2. Similar to 'Patch set', each color was measured using a camera and the spectroradiometer at the same position.

As a camera characterization model, simple 3x3 matrix was used since the camera RGB values showed the linear relationship with the luminance of the measured color. To optimize the model parameters, three training sets i.e. 'Patch Set', 'Monitor set' and 'All set' combining both 'Patch set' and 'Monitor Set' were used by minimizing the CIELAB ΔE^*_{ab} values between the measured and the predicted CIELAB values. For CIELAB calculation, the white color in the viewing booth was used as the reference white since that color showed the highest luminance.

As a result, it is found that when small color gamut was used as a training set, colors located outside the color gamut of the training set showed the poor performance. Also when wide color gamut training set was used, overall performance was improved. This result indicates that the color gamut of the training set should be large enough to improve the performance of the camera model for wide range of colors.

PS1-48

Reproducing the Old Masters: A Study in Replicating Dark Colours with Inkjet Printing

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ABSTRACT

One of the major difficulties in the inkjet reproduction of Old Master paintings is the replication of darker paint passages. This reproduction of very dark colours, can involve heavy uses of black ink to darken colours in order to approximate the original shades. However, this can reduce the apparent differences between colours with similar darkness levels as the options for generating the sample areas are limited by the number of colourants that can be used. With this research we propose to extended the available range of dark colours by incorporating the use of direct channel and multiple pass printing techniques, facilitating improved colour matches to original darker paint passages observed in paintings in the National Gallery Collection.

By incorporating direct channel printing technologies we can specify the optimal colourant combinations most suited to generating each specific match, allowing for a greater level of refinement in reproducing the final colour. Additionally, by employing multiple pass printing we are able to apply more than one layer of colour, increasing the ink density and darkening colour without the inclusion of black ink.

This allows us to generate a wider range of dark colours, building them up from layers of lighter inks, minimising and or eliminating the use of black ink and maintaining better colour subtlety between dark values of hue.

For this study we will sample colours within dark regions of a small selection of target paintings from the National Gallery Collection and generate colour matches to these areas using the techniques described above. These samples will then be compared against results produced through traditional print reproduction workflows. The aim of this research is to investigate the potential benefits of incorporating these printing techniques in future reproduction workflows, expanding the available gamut of darker colours and improving the colour accuracy of inkjet print reproductions which include darker paint passages.

PS1-49

A New Metric for Evaluating the Closeness of Two Colors

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ABSTRACT

In order to estimate the difference of colors, metrics describing color difference such as CIEDE2000 and CIE76 are widely used. They are suggested to use when the color differences are relatively small. When it comes to evaluate two colors whose color difference are large, we would need a new metric which can well express their differences. Evaluating the difference of two colors would be equivalent to evaluate how close those two colors look. Instead of direct comparison of the color difference/closeness, it would be also possible to compare colors with some intervening color.

In this study, we try to propose a new metric based on the hypothesis mentioned above. We assume that each color has several “corresponding colors”, which give the impression or the appearance of that color to be identical or at least similar. If those colors form a trend-line, a new metric to be proposed should describe how far a given color would be from this trend-line. We call a series of the color on the same trend line “consistent color”.

First we tried to find consistent colors for several reference colors. 12 saturated colors of different hue were selected as reference colors. In order to find a trend line of consistent color for each reference color, we need several different color gamut whose surface will cover differently. We used several CRPCs (Characterized Reference Printing Condition) proposed by CGATS. A subject could change the test color on the surface of a given CRPC (either CRPC7, CPRC5, or CRPC3), until the test color appeared the most similar, or closest to the reference color. After conducting the setting for three times for each test color, the mean value was adopted as the consistent color for that CRPC. By fitting the consistent colors of different CRPCs, we could obtain the trend line for consistent color appearance.

Secondly, by conducting magnitude estimation experiments to evaluate how close the displayed colors to be to the consistent with a given test color, we would be able to find the best color on the trend line, and also quantitative evaluation of their closeness. Then we would be able to define a new

metric to best describe their closeness. In the conference, we would expect to report our findings.

This new metric could be applicable to predict how close a color, which are transformed in a specific way, to the original color.

PS1-50

Image and Color Space Clustering for Image Search

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ABSTRACT

I'd reported a study of image search method based on color data in image pixel. In this previous study, it employ filling region data as search index data. This approach success to pick up image of almost same image toward source image, its searching target.

This new study report an approach by image space and color space clustering by MacQueen(1967) based method of Yamamto,Murakami(2003) method. K-method in MacQueen(1967) improved clustering method by pre-fixed clustering region. Yamamoto,Murakami(2003) suggest new method, that is better than K-method in point of clustering number is changed according by each image. Because the best clustering number for each image, is not able to know before actual clustering process. Yamamoto,Murakami(2003) method is based on pixel color in first and does ad-hoc method in later. This study propose color space clustering method based on K-method and image clustering method based on Yamamoto,Murakami(2003). Then report a result to apply image searching application.

PS1-51

Restoration of Color Appearance by Combining Local Adaptations for HDR Images

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ABSTRACT

Color LED lights are widely spreading even as consumer products, and accurately displaying the color effects of such scenes with captured images become important for informing their effectiveness, which is utilized for lighting design, advertisement, and so on. The colors of the images, however, are often saturated or fade-out for the scenes illuminated by vivid colored lights, especially in very bright spots.

This research focuses on such degradation of colors for high dynamic range (HDR) images that can fully capture the brightness and color of the scene at high bit-depth. The dynamic range should be compressed to fit that of ordinary color monitors, and color appearance model (CAM) is widely used for authentically reproducing colors in compressions. This model, however, is ineffective for the scenes including vivid lightings, and we therefore propose a robust color reproduction using the spatial adaptation for the scenes captured as HDR images.

Our method introduces an image appearance model called iCAM06, which has the spatial adaptation based on CIECAM02, to the illuminated HDR scenes.

Though human visual system can adaptively perceive accurate colors for each local region, we remap such local adaptation to a single image for efficiently and effectively displaying the overall atmosphere of the color illuminations.

The existing technique of synthesizing a spatial adaptation map is extended with a bilateral filter, whose spatial and range parameters are utilized to approximately control a field of view and a model of lightness perception. We experimentally found that the adaptation for smaller regions causes lesser artifacts on the compressed image, while fully reducing the color fade-out effects. We demonstrate the efficiency of our method by visually comparing the reproduction results against conventional methods.

PS1-52

Image Quality index for perceiving three-dimensional effect in mobile displays

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ABSTRACT

Recent years, with the development of mobile displays, more wide-gamut, high resolution and high contrast mobile displays have been published. To understand differences in perceiving three-dimensional effect between mobile displays, and precisely estimate in which condition mobile displays perform it well, we conducted two experiments. One was for evaluation of image quality index of color and sharpness, another was for evaluation of depth perception. Analyzing visual evaluation data, we have developed two kinds of image quality indices; $\boldsymbol{IQI}_{\text{color}}$ and $\boldsymbol{IQI}_{\text{3D}}$.

We prepared 9 mobile displays, including LCD and AMOLED displays. In $\boldsymbol{IQI}_{\text{color}}$, we measured the colorimetric specifications of each device with 4% pattern by using a spectroradiometer. We measured the *XYZ* tristimulus values of eight typical color stimuli of red, green, blue, cyan, magenta, yellow, white and black. As $\boldsymbol{IQI}_{\text{color}}$ is supposed to be related to three parameters: color volume, luminance contrast and resolution, we defined each index including three parameters.

Color volumes were calculated in the CIECAM02-UCS color space. Since the color volume of optimal color is 2,334,000 in CIELAB unit, we defined relative color volume index (RCV) as color volume divided by 2 million. Then, luminance contrast ratio index (*CRI*) was defined as a ratio of maximum and minimum luminance instead of usual Michelson contrast. The resolution index (*RI*) was defined as the pixel per inch of mobile display divided by 582, corresponding to the limit of retinal resolution for visual acuity 2.0 at the viewing distance of 30cm for normalization.

In $\boldsymbol{IQI}_{\text{3D}}$, it should be related to four parameters, color volume, luminance contrast, resolution and display size. The first two parameters were as same as $\boldsymbol{IQI}_{\text{color}}$. We defined the resolution as pixel per degree ($\boldsymbol{RI}_{\text{retina}}$) divided by 100, corresponding to the number of cones in a visual angle of one degree on a fovea.Then, display size in degree ($\boldsymbol{RDS}_{\text{retina}}$) was divided by 1440, based on an assumed optimal visual field for viewing image, 48º x 30º.

In $\boldsymbol{IQI}_{\text{color}}$, we selected three pictures from Standard High Precision Picture (SHIPP) data, and conducted a paired comparison experiment. A visual image quality performance was provided by Z-score from the experiment. The correlation coefficient of 0.952 indicates strong relationship between $\boldsymbol{IQI}_{\text{color}}$ and Z-score.

In $\boldsymbol{IQI}_{\text{3D}}$, we selected five pictures and one movie to conduct paired comparison and subjective evaluation experiments. Fifteen observers with normal color vision participated. We used the least squares method to find the best-fitted parameters of $\boldsymbol{IQI}_{\text{3D}}$ to the experimental results. Finally, we made one-way ANOVA to make sure the devices have differences in perceiving three-dimensional effect, and then we used t-test in each result of subjective evaluation. When $\boldsymbol{IQI}_{\text{3D}}$ differences are over 0.07 on heterogeneous displays, observers can discriminate three-dimensional effect easily. As the same way, $\boldsymbol{IQI}_{\text{3D}}$ equal to 0.24 can be regarded as the base rate of subjective evaluation. We can know how much the three-dimensional subjective feeling will be.

Thus, our results suggest that $\boldsymbol{IQI}_{\text{color}}$ represents perceived image color qualities sufficiently and $\boldsymbol{IQI}_{\text{3D}}$ provides an easy way to discriminate the three-dimensional effects between heterogeneous displays.

PS1-53

Imageries of Edible Souvenirs Evoked by Colours and Visual Textures of Packages

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ABSTRACT

In the recent few years, Taiwan's travel industry has witnessed a surge in tourist numbers and the spending by tourists in souvenirs has increased accordingly. This has led to a larger yet more

competitive market of tourism souvenirs, i.e., commemorative merchandise associated with a location to provide tourists a memento of their visit and to encourage an opportunity for a return visit. Thus, seeking approaches to highlight features and to create a unique identity (e.g., product feature, brand images…etc) for tourism souvenirs has received a great deal of attention from package designers. Among many aspects, colors and visual textures of packaging materials are two essentials of design that conveys product features and brand images.

Papers and cartons are the most frequently-used packing materials which contain numerous types of appearance. In the current study, we aim to examine the relationship between imagery and appearance of packing papers in terms of colours and visual textures.

To achieve this, we firstly collected words that are used to describe appearance of packing papers (e.g. rough and smooth) and moods of design (e.g. elegant and traditional) in the context of edible souvenirs. These words were collected from relevant studies and verbatim of interviews for design experts. Secondly, we collected 10 frequently used packing papers. Each of them was printed using 20 colours. The 20 colours were selected to give a reasonable coverage in CIELAB space. Thirdly, we adopted semantic differential and asked 25 participants to visually assess the 200 colour-printed packing papers (i.e. 20 colours across 10 packing papers). Each of the packing papers was presented in a form of a 20*12*4 cm^3 box. This was to simulate the papers being seen in the context of souvenirs. The participants were asked to evaluate stimuli according to the appearance of the largest side of the boxes (i.e. the side of 20*12 cm^2).

The experiment is still in progress. According to the observation during the visual assessments, we expected an insignificant gender difference. We also expected that agreements between participants were better for assessing the appearance than assessing the mood of design of packing papers. Several interesting phenomena were also expected, such as rough papers looked more traditional than smooth papers did.

In the full paper, the details of experimental set up and the results will be given. The imagery of colours in the context of packaging for edible souvenirs will then be discussed, followed by the discussion of the influence of visual texture on colour imagery.

PS1-54

A Study of the Preference and Orientation of “the Sense-oriented”

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ABSTRACT

The purpose of this study is to compare the preference and awareness of people who are actively interested in color, design, art and fashion with those of the average- and low-interest groups and to clarify their characteristics.

The survey was conducted on 1440 Japanese male and female subjects, aged 18 to 69 years. The questionnaire consisted of two parts: the first involving color preference and color image, showing 46 colors, 30 samples of the five-colors-combinations, 48 patterns and some photographs of various items in daily life such as interior designs, clocks, cars, etc.; and the second consisting of 20 questions on awareness of taste, such as, “Have you confidence in your sense of color ? “, “Do you often go to the event or exhibitions of art and design ?” and “Do you buy cheaper thing even though that is not your favorite color and design ? “. The subjects are asked to answer each question by choosing on the 5-point scale.

The outcome of the factor analysis indicates: Factor I for the acquisition of the information and Factor II for the positive behavior for colors and design. Then by cluster analysis, four types are identified: group 1 that considers that senses are very important (15.6%), group 2 that considers that senses are rather important (35.0%), group 3 that thinks that senses are somewhat important (26.9%) and group 4 that is least interested in senses (22.5%). Group 1 shows the male-female ratio is 37% to 63% and consists of more younger people than the other groups. After conducting the cross-tabulation, four clusters were profiled by taste, interest and awareness.

As a result, the group 1, “the sense-oriented group”, made more choices in multi-answer questions than the other groups, and showed certain characteristics in the categories they were interested in. For example, women of group 1 selected the words, “classy”, “elegant” and

"sophisticated" as their favorite images, while those of group 4, "the low-interest group" chose the words "comfortable", "uncluttered" and "rustic".

For their favorite material, group 1 selected cashmere and silk, while group 4 chose cotton and traditional Japanese paper. For color preference, group 1 selected, among others, cool colors such as marine-blue, turquoise and gold that are not preferred by the other groups. As for purchasing awareness, the ratio of people who agreed with the statement "When you go shopping, you regard the feel of texture and material as important." was higher in the group 1 than the other groups.

PS1-55

Color Preference Measured by Paper-Format Implicit Association Test

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ABSTRACT

In a history of research concerning color preference, preference judgment has been measured via explicit behaviors, such as verbal report and so on. In many recent psychological studies, however, it has been indicated that expressed attitude measured with explicit methods often differs from underlying implicit attitude. In our recent studies, we have tried to measure participants' implicit attitude toward color, and succeeded to measure their implicit color preference by analyzing strength of implicit associations between a psychological concept of goodness and specific colors. These investigations might contribute for our better understandings about underlying psychological mechanism in generating individual color preference, and also for developing new and effective methods that we can utilize in measuring color preference. In our previous studies, we employed conventional computer-based implicit association test (IAT) in order to measure implicit color preference. In IAT measurements, the participants were asked to press designed keys in discrimination tasks, and implicit color preferences were calculated based on the differences of reaction times. The procedure is suitable for measuring the participants color preference with avoiding their intentional indications (thus, measurements must be implicit). On the other hand, conventional IAT measurement requires considerable test durations in isolated individual experiments. It makes researchers difficult to collect data from mass participants and grab general tendencies concerning color preference in specific groups. In the present studies, we tried to measure the participants' implicit color preference using paper formatted IAT. It makes us enable to execute psychological experiments simultaneously in a massy group to collect preference data from considerable number of participants. In a paper-and-pencil style IAT, the participants were asked to manually tick a list of discrimination targets (printed on paper), instead of a computer-based key pressing. We can assess relative implicit color preferences by calculating differences of number of the items that the participants could make judgments. Over 200 undergraduate participants took part in paper-format IAT to measure relative preference between red and green, blue and yellow, and also black and white. Target colors were presented by either color names or objects which can easily make the participants recall specific colors (both of them were displayed in Japanese characters). Two separated paper-format IATs were repeated with inter test interval of one month. Results of psychological experiments indicated that 1) correlations between implicit color preference measured by paper-format IAT and explicit color preference measured by visual analogue scale (VAS) were relatively low but still significant, 2) correlations between implicit and explicit color preferences were varied with different target colors (red-green, blue-yellow and black-white) and difference color presentation (color name and object name), and 3) correlations between two distinct IATs were considerably high. These results suggested that paper-format IAT holds a considerable reliability (and a certain validity so far) in measuring relative implicit color preference, and we can utilize it for measurements of color preference in a group experiment.

PS1-56

SSVEP Response Study for Low Semantic Images

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ABSTRACT

In our research we have studied a potential relation between Steady-State Visual-Evoked Potentials (SSVEP) responses, some low level images features and the emotion arousal. In the literature numerous papers refers to this kind of study made on IAPS [1]. This database is dedicated to emotion study and it contains many images carrying a strong semantic. From the experiences on this dataset, the amplitude, latency and topography of the SSVEP response have been proven to be correlated to the arousal and valence of the shown pictures. Our aim is to test if this conclusion can be extended for low semantic images: could SSVEP response also be used to study the affective content of natural images that were not specially created to elicit emotional responses?

We chose 12 images from our new database SENSE (Studies of Emotion on Natural image databaSE) developed for this kind of tasks. They were assessed according to the nature and the power of the emotion. During the tests, we recorded the EEG of the 4 participants while looking at the images. The images are evaluated during three trials and presented in each one on a different pseudo-random order. For each trial, an image was displayed for 8s and flickering at 10Hz. After displaying the image to assess, a black image is displayed for 5s. The EEG was recorded from 4 electrodes positioned on the occipital area on Pz, POz, PO3 and PO4 location according to the 10-20 system.

We evaluated the correlation between the computed SSVEP responses and the pictures across different trials and observers to be sure there is a significant modulation of the response due to the pictures content. We also estimated the correlation between the SSVEP responses and the arousal, the luminance and the Gabor energy for each images.

From the obtained results we can confirm that for the considered natural images there is a clear and strong correlation between the pictures and the SSVEP response elicited in the observers. On the other side, at this stage, we cannot identify which are the main image features modulating the SSVEP response; a clear statistical significance could be reached by performing the experiment on a higher number of subjects and/or using a higher number of images.

[1] P. Lang, M. Bradley et B. Cuthbert, «International affective picture system (IAPS): Affective ratings of pictures and instruction manual. Technical Report A-8,» 2008.

PS1-57

My Own Colour

Kristiina NYRHINEN
studio Kristiina Nyrhinen

ABSTRACT

”My own colours”
The nature has always been the most important source for the art in Finland.

Is this the truth or is it a cliché or a mantra that we Finns keep on repeating, while we have the opportunity to tell someone about our art.

The truth is that we as a country have a large surface, but we are small in population. The countryside surrounds every city, even the capital is close to the nature. It takes less than an hour to be on the fields and forests alone or enjoy solitude on the small island nearby.

In my generation almost everyone has roots in the countryside, grandparents and relatives still live there. Also many families living in the city have a little summer cottage somewhere in the woods,

isolated by the lake.

I lived my childhood in the countryside by a large lake. The changes of the four seasons were easy to observe there. The first signs of the spring were seen in the lighter colours and brightening light. Suddenly the ice disappeared and the lake was blue and glittering again. Also in the autumn when the funny scratchy noise was heard from the lake as a fanfare before the first cold night and a very thin ice was formed on the lake. The winter had come.

Now I live and work in a city close to the capital but still in the forest. I can't feel the changes of the seasons so easily and clearly as before. I've grown to know the seasons inside me and I can see its influence in my artwork. I don't know the trees and vegetable world very good but I enjoy the atmosphere and the colouring of the forest and meadows.

My early work, the huge, transparent textiles, in the public buildings was highly influenced by the big lake near my home and water in general. I've used water like materials and shades to reflect the rich palette of the water.

In my childhood I've looked my mother planting and watering plants in the garden. From her garden she harvested vegetables for the table and flowers for the eyes.. And now in three years time I have a small patch of land of my own where I care for my peonies and lilies. Now my textile works have changed a lot. I've studied flower petals, how they grow and fade away. And I've noticed that the form becomes more exciting and the colours become darker. I reflect the garden of my mothers in my art, the hues of blue, red and yellow. I work with the metaphor of ageing and fading-out.

PS1-58

Hue and Tone Effects on Color Attractiveness in Mono-Color Design

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ABSTRACT

One cannot deny the fact that nowadays there are serious competitions in the market. Marketing practitioners know that a product's color may play an important role in a consumer's purchase decision. About 62-90 percent of the assessment is based on color alone. So, prudent use of colors can contribute not only to differentiating products from competitors, but also to influencing moods and feelings –positively or negatively- and therefore, to attitude towards certain products. For building up a market share, designers must be created products which are interesting and attract the customer's attention.

One of the important roles for catching a customer's attention is to color attractiveness of product package. It indicates a characteristic that which product can be distinguished most clearly among various products. It said to be that a colorful package attracts a subject's attention and to arouse the desire to consume in marketing. Regarding the environmental conservation matter, ecological design, eco-design, seeks to conform to the environment and substantially reduce material consumption. Monochromatic design in printing has been noted as alternative technique as eco-design. Amount of ink on substrates for this design is less than that for color printing in the printing process. Moreover, this design reduces the printing troubles and cost of a product. Although monochromatic design seems to conform to eco-design, the color attractiveness is required for a product design. It would like to know how to catch customer's eyes with the monochromatic design. Several factors are said to be responsible for color attraction for instance differences in age, gender, culture and so on.

The major aim of this study is to investigate the effect of monochromatic color on attractiveness. A psychophysical experiment was carried out to examine the relationship between color attractiveness and single color and color tone combinations. In experiment I, seventy seven color chips varying in hues and tones were simulated on monitor as stimulus. Five subjects were asked to evaluate a color attractiveness score for giving color by using an attractiveness rating scale. The experimental result will show the relationship between color attractiveness and hue and tone. In the experiment II, patterns for color tone combinations were investigated. Color tones were classified into three groups as highlight, middle-tone, and shadow. A color attractiveness of the patterns was evaluated by an attractiveness rating scale. Effects of hue and tone will be reported in the expected results. The effect of the patterns for color tone combinations is also explored.

PS1-59

A Study on Silver Metallic Color Preference -A Comparison of Responses between Japanese and Thai People-

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ABSTRACT

We've researched the designing conditions for more attractive surfaces of the industrial products in cooperation with a material manufacture. It is significant for us to understand the customers' visual preference for each product in each nation. We are investigating the relationship between the customers' desired feelings and the surface colors of silver metallic products among Asian nations by an on line survey. In this presentation, we'll show you the comparative results between Japanese and Thai people.

A questionnaire on the Web was used for our investigation and written in Japanese, Thai, and English. Computer graphics were used to represent the metallic surface products such as a fridge and a DVD player. Those have slightly different silver colors: reddish, yellowish, bluish, and so on, and each of color was controlled in ten hues of the Munsell color system. We set five target feelings: "clean / pure", "stylish", "high-quality", "relaxing", and "favorite", which were chosen as the most important feelings for the metallic product by Japanese customers. The respondents answered with the color that they felt was the most "clean / pure", for example, for seven target products: a fridge, a television, a laptop computer, and so on. More than five hundred persons from Japan and Thailand have cooperated with us in total and we've compared the results between two nationalities.

As the result of the survey, it became clear that most people preferred the bluish silver color for the feeling of "clean / pure" in every product. Especially, Munsell **B** had the largest followers in both Japan and Thailand and **BG** was also higher in Japan. Many Thai people selected **BG** in every product for the feeling of "relaxing / comforting", however, many Japanese selected **YR** and **B**. On the other hand, Japanese and Thai people were similar in the tendency for the feeling of "high-quality". Moreover, we examined how much the response was affected by his/her "birthday color", because everyone in Thailand has his/her own special color depending on birthday that based on an ancient Buddhist wisdom. However those were not found to have a correlation. In addition, we newly found from other additional questions that Thai people's color consciousness is very high in comparison with Japanese. And many Thai desired the feeling of "modern" for the metallic products. This adjective is not included in the top twenty in Japan. We need to additionally examine the silver color preference that Thai people feel is the most "modern".

The results from this survey are very useful for a manufacturer to fit the design concept in each nation. It is necessary for us to continuously analyze the data from cultural and social points of view and link to predict the customers' preference in future.

PS1-60

Colors' Relations to Other Things in My Works

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ABSTRACT

I see my works in textile art as traveling trough colors, shapes and materials. First I thought that technique was most important (I discovered how I can weave twelve layers' fabrics). Now I'm more interested in how to get the color, the sculptural shape, the material and the light work well together, to give an emotional experience.

Making textile art is an endless way of questions:

How much I can think of myself, my ideas, my wishes, other people and all the demands of the commercial point of view. As for colors, everyone has his or her own color taste. Should I and can I give new experiences of it and what is the ultimate meaning of my work.

The art piece must be so strong that it takes its space where ever it will have its role in the future and the co-operation with the environment. How important is the color right now? Does it shout or whisper? Both shouting and whispering could be strong items. And the emotional point of view! Is it white clean and pure or black, dark or silent? For me the color is the first thing I see in an art piece. It opens the work.

It calls or draws you away.

I'm fascinated in architectural bridges. They lead you somewhere and at the same time they combine you with someone. They inspire me and when the structure is strong the color must support it like material does too. I found the Japanese flat silk yarn so sensitive and strong at the same time. I dyed it and it took the color precisely the way I wanted.

In textile Art there are so many ways to use color as a tool.

The color combinations are most demanding, can you make the colors alive and interesting new versions.

The right color gives more to the material but you can also kill the feeling.

The best thing in colors is that it is like poetry, you just have to let your imagination be free.

PS1-61

Color Preference of Preschoolers: Compared to Adults' Surmise

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ABSTRACT

Previous studies show that color preference of human varies across different culture, gender, age, race and educational background. Personal experience and personality also would affect the choice of preferred colors. In addition, the preference could be object dependent. For example, an individual would prefer black shoes but dislike a black wash machine.

The aim of this study is to investigate the color preferences of young children aged 4~5 and to compare with the viewpoint of adults in color preferences of the children. Based on the truth that preschoolers receive minor influence from environment comparing with adults, it's interesting to know is if adults' opinions agree with the young children'. The effects of gender and the association of objects also were analyzed.

In this study 15 color samples were chosen including: pure red, orange, yellow, green, blue, purple, black, gray, white, and six additional colors selected from Angela Wright's Personality Type 1 Morning Light Color. It contains pink, light orange, light yellow, light green, light blue, light purple. These six colors are relatively bright and low chroma. We used these 15 colors to produce color patches, mini T-shirts and candy-shaped packaging as test samples.

19 children of four to five-year-old from a kindergarten in Taipei participated in this study to test their personal color preferences on color patch, T-shirt and candy-shaped packaging. This study also investigated 15 single adults aged of 23 to 25 for guessing the color preferences of the preschoolers on the three types of object.

The experimental data were analyzed by SPSS statistical software (version 19), and the results are summarized as follows:

(1) The general color preference of the preschoolers listed in descending order is: pink, light green, light blue, light yellow, gray, white, light purple, red, purple, and blue. Pink and light green are the most favorite colors for the girls and the boys respectively. In comparison with the two genders, the boys do not like pink and red whereas girls are not interesting in light green and green. In general, the preschoolers prefer bright colors with low chorma.

(2) While the boys prefer a black T-shirts, the girls in contrast like white T-shirts. It seems that children like neutral colors when buying a T-shirt. Their secondary choice is light blue.

(3) Boys like orange and girls like red and pink in choosing a candy.

(4) The adults think that the most favorite color of the girls must be pink in the color patch and T-shirt

items, and the most favorite color of the boys should be light blue for the color patch and light yellow for the T-shirt. The adults' results are quite different from that of the preschoolers'. So, parents and manufacturers should give more freedom to young children in choosing color products.

More results will be reported in the full paper.

PS1-62

Influence of the Typical Color in Object Memory Task

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ABSTRACT

This paper presents experimental results of a work on the change in the memory of color. The work was done by using mutual color of adjacent two color categories. In the previous research, it was thought the change of memory of color could be restricted within the color category. However, we found that the memory of color may change to the direction of typical color of each object when two kind of the object images with same color are presented. It suggests us that the knowledge on the typical object color may affect to the recognition and memory of color even beyond color categories.

PS1-63

Neural Basis of Color Harmony and Disharmony Based on Two-color Combination

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ABSTRACT

In this study, individual color-harmony scores were determined by rating experiment prior to functional imaging study. Each participant rated 351 two-color combinations stimuli presented against a grey background on a 9-point scale. Based on the results, we made individual data sets for each participant to optimise the subjective experience of color harmony and disharmony; then we selected 30 stimuli in each class according to highest, middle, and lowest scores. We conducted functional magnetic resonance imaging to determine the brain regions activated by harmonious and disharmonious color combinations in comparison to other stimuli. Each participant was instructed to rate a stimulus on a 3-point scale (1: Disharmony, 2: Neutral, 3: Harmony) within 2500 ms. Image processing and analysis were performed using SPM8. During the presentation of Harmony stimuli, we found that the left medial orbitofrontal cortex (mOFC) was activated, while, bilateral amygdala and right inferior frontal gyrus were activated under the presentation of Disharmony stimuli. We observed the association between color harmony and perceptual properties by using a simple two-color combination stimulus in this functional magnetic resonance imaging (fMRI) study. To quantify the relationship of two colors, we introduced five indexes based on CIELAB color space, i.e. difference in lightness (ΔL^*), mean lightness ($mean\boldsymbol{L}^*$), difference in chroma (ΔC^*), mean chroma ($mean\boldsymbol{C}^*$), and difference in hue (ΔH^*). This experiment revealed that there were no significant differences between Neutral and Harmony stimulus combinations, however, Disharmony stimulus had significant differences in ΔL^*, $mean\boldsymbol{L}^*$, $mean\boldsymbol{C}^*$ and ΔH^* in comparison to Harmony or Neutral. We found that color disharmony depended on perceptual properties of the actual stimulus. Taken together, our findings suggest that color disharmony depends on its stimulus properties and unconscious neural processes mediated by the amygdala, whereas color harmony is harder to discriminate based on color characteristics and is supported by processing aesthetic value within the medial orbitofrontal cortex.

PS1-64

Psychological Hue Circle of Blind People and Development of a Tactile Color Tag for Clothes

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ABSTRACT

The totally blind persons have strong interests in color though they can't see color. Ladies in particular like to know colors of the clothes they are wearing and like to enjoy color coordination of their clothes. In order to meet this request, we first studied how the color is represented in the perceptual world of totally blind person and secondly tried to look for the best way to let them know the color of clothes.

Our scientific interest was mostly focused on how the color is understood by congenital blind who have had no experience of seeing color in their life. After a questionnaire on what color names they know in their daily life, it was found that most of the basic color terms were understood by persons with total blindness and this led us to conduct on color scheme experiment on the basic colors using MDS (multidimensional scaling) method. We asked all the 16 totally blind persons, some of them being congenital blind, how far (or near) the two color terms given in verbally was considered apart and to answer in 5 point scale from very far to very near.

Ten basic colors based on Munsell color system were used so that 45 pairs of color names were tested. The result showed that 13 persons including 10 congenital blind persons showed a clear color circle with the right order of hue was obtained. The resting three persons, who failed to show a color circle, were all men rather aged and confessed no interest in color in their life.

Being based on these findings, we designed a tactile color tag with a circle made by ten small tactile dots one of them being a larger dot (or make a hole) to show the color to be known. Some tactile experiments were done to confirm the appropriate size of the color circle and a tactile dot size (small or large, or a hole).

Finally, we developed a color tag to convey color information to the blind which has two circles with an outer circle of vivid colors and an inner circle for pale colors as well as achromatic colors (white grey and black) in the center of the circle like the color space. Test tags were made from a few materials (acrylic button, embroidery, and artificial leather) and attached them to T-shirts with different colors. All the 10 blind subjects participated in the identification experiment showed almost perfect performance (93 % correct) in identifying colors of the T-shirts. The design was successfully proved to be useful to convey color information to the blind. It is finally noted that from its color circle the blind person can also enjoy a combination of colors from the positions of the colors in the circle so that near means similar or far means high color contrast.

PS1-65

Examination of Method for Decreasing Unpleasantness Caused by Strong Brightness of Smart-phone Displays in Dark Adaptation

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ABSTRACT

Nowadays, smart-phones and tablet PCs are used very much in our daily life, and the opportunity to work by seeing their displays has been increased. Many of such display media is a self-luminous display. The regulation function of the display can adjust luminance according to the luminance of surrounding environment, and users can see images and characters on the display automatic-controlled luminance. However, it is not clear whether the brightness self-adjusted is suitable for smart-phone users or not.

The aim of this research is to suggest a method for decreasing the unpleasantness by the strong brightness on a display which the user of a smart-phone has under dark adaptation. In this research, a questionnaire survey was conducted about the unpleasantness which subjects feel to the dazzle of a

smart-phone display to 20 smart-phone users. Then, a visual experiment using iPod touch (same form to iPhone) manufactured by Apple Inc was conducted that 30 subjects evaluated the impression and the unpleasantness caused by the brightness of the smart-phone display with different brightness and background colours. The replies obtained in the questionnaire survey and the experimental results were analysed. It authorized whether a significant difference would be between each evaluation result, and investigated correlation with luminance. Through the analysis of the experimental results, the followings were found out;

1. The 4 kinds of impressions to the brightness in each conditions, which are 'dazzle', 'fatigue', 'irritation' and 'unpleasantness', have high correlation to luminance.
2. The favourite luminance to use a smart-phone display was found out. In addition, at the time of dark adaptation, it was found out that brightness lower than the brightness given by the self-adjustment function of a smart-phone display reduces the unpleasantness. Moreover, the unpleasantness can be reduced by changing a background colour to black, even if the brightness was given by the self-adjustment function.

PS1-66

A Spectral-based Color Vision Deficiency Model Compatible with Dichromat and Anomalous Trichromat

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ABSTRACT

This paper proposes a spectral-based color vision deficiency model with compatibility both for dichromats and anomalous trichromats. Most of the color blind simulators follow the Brettel-Vienot-Mollon's model, and have been widely accepted, but any of them didn't clarify what spectra are captured as visible or lost as invisible. In the previous papers, the author proposed a spectral-based dichromatic vision model based on the"Matrix-***R***" theory extended to the 2-D dichromatic version. The novel model extracts the visible and invisible spectra to dichromats based on the projection theory of spectral space to/from 2-D dichromatic cone space and extracts the lost spectra as a difference in the fundamentals between the normals and the dichromats. The lost spectra are re-used for image daltonization by an optimal spectral shift algorithm. Though the lost spectra are invisible if left alone, they are shifted into the visible spectral region and added to the *fundamental* ***C**** of source image. As a result, the dichromatic image visibility is dramatically improved. The optimal spectral shift is determined to maximizing the spectral visibility for the dichromats and minimizing the visual gap from the normals. The proposed algorithm is designed to solve a contradictory demand to cope with both dichromats and normals.

While, actually, the anomalous trichromacy outnumbers the dichromacy. According to the statistics in Japan, it's reported that 15 % protanomaly and 46 % deuteranomaly outnumber 9 % protanopes and 30 % deutanopes in average (Ichikawa 1982).

This time, the author extended and unified the basic algorithm to be compatible with the anomalous trichromacy as well as the dichromacy. The proposed model works based on the key ideas of

[1] First, the *fundamental* ***C**** (called fundamental metamer, visible spectra to the normal vision) is theoretically extracted from the conventional sRGB camera images by a pseudo-inverse projection.
[2] Projection matrices Rdic for dichromacy are composed of choosing a pair of [$m(\lambda)$ $s(\lambda)$)] for protanopes and [($l(\lambda)$ $s(\lambda)$)] for deutanopes from LMS cone spectral sensitivities{($l(\lambda)$, $m(\lambda)$, $s(\lambda)$)}..

As well, Ranom for anomalous trichromacy are created a set of [$la(\lambda)$ $m(\lambda)$ $s(\lambda)$)] for protanomaly and [l (λ) ma(λ) $s(\lambda)$)] for deuteranomaly. Here, the anomalous cone responses la(λ) and ma (λ) are created by mathematically describing the table data given by DeMarco & Pokorny & Smith (JOSA,1992).

[3] The *fundamentals* ***C****dic or ***C****anom visible to the dichromats or anomalous trichromats are obtained by operating the extended matrix Rdic or Ranom on the *fundamental* ***C**** in the step [1] based on matrix-***R*** theory.
[4] The opponent-color process is necessary to keep the grayness, where the perfect opponent color space with golden-vectors is newly introduced.
[5] The lost spectra Δ***C***dic or Δ***C***anom are calculated as the difference between ***C**** and ***C****dic, or ***C**** and ***C****anom for dichromats or anomalous trichromats, respectively.

[6] Finally, the lost spectra $\Delta \boldsymbol{C}$dic or $\Delta \boldsymbol{C}$anom are re-used for daltonizing the image visibilities to dichromats or anomalous trichromats by applying the optimal spectral shift algorithm proposed in the previous paper.
[7] The simulated results are compared with the related other methods.

PS1-67

Colour Information in Design

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ABSTRACT

This study is concerned with identifying which types of colour information are useful in packaging design and branding. Throughout the design process, a considerable range and volume of information is generated, used, referred to, and consulted with (Baya et al., 1992). Useful information in design can assist to save duplication of effort and time and to simulate creative energies (Wodehouse and Ion, 2010). Colour information is defined as interpretations, abstractions and knowledge about colour data in various fields, which include natural sciences, technology, art, psychology, cultural studies, history, and design. Colour conveys products' messages, and influences consumers' attention and their purchase decision-making (Klimchuk and Krasovec, 2006). Yet despite the importance of colour in design, it has tended to be regarded as secondary (Leeuwen, 2011). Furthermore, due to the multi-disciplinary nature of colour, it is not clear whether colour information is effectively utilised in the design process. Colour information is a relatively new area that has not yet been addressed in detail by design research practically or theoretically. In this sense, it is noticeable that there is currently a lack of study on colour as information in design. Therefore, in order to support design process through the provision of useful information, identifying what information should be captured for design would be both needed and helpful.

In order to explore which colour information is useful in packaging design and branding, multiple methods such as analysing literature, online survey and face-to-face interviews were carried out. An analysis of the literature (299 journal papers and 10 textbooks) identified thirteen types of colour information. The importance of these thirteen types was explored through an online survey (N=62) with participants (identified through LinkedIn with a strong interest in packaging and branding) and face-to-face interviews (N=9) with senior designers and brand managers. The results from the online survey and the interviews were broadly consistent (r2=0.633) and identified *harmony*, *perception, printing, notation*, and *meaning* as being particularly important. This study will provide valuable insights for designers and brand managers informing which colour information are useful for their design process.

PS1-68

Relationship between Perceived Whiteness and Color Vision Characteristics

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ABSTRACT

Fluorescent whitening agents and bluish dyes were added to white clothing and printing paper to evaluate these objects increased perceived whiteness. This was done to take advantage of the color components that contribute to the perception of brightness. Until now, research on the effects of color on perceived whiteness has been conducted for persons with normal color vision. However, comparisons with color deficient observers have not to be made. This study investigates the relationship between the color vision characteristics of observers and their perceived whiteness, with

regard to near-white stimuli with a variety of hues.

We used a liquid crystal color display, in which the white point was adjusted to match the chromaticity of the standard illuminant D65. Twelve types of near-white stimuli were then presented to the observers. We prepared the hues of the stimuli to be exactly 10PB, 3PB, 5B, 7BG, 9G, 3G, 3GY, 5Y, 4YR, 4R, 7P and N in Munsell notation; the lightness as 9.5 in Munsell notation; and the average Munsell chroma as 0.25, with the exception of the achromatic stimulus N. Using a paired comparison method, we told each observer to choose the stimulus that he or she determined to be whiter. The stimulus pairs were presented in random order, and the observers were told to evaluate them twice. The observers consisted of 15 persons with normal color vision (N-type), seven persons with Dichromatic Protanopia (P-type), four persons with Anomalous Trichromatic Protanomaly (Pa-type), seven persons with dichromatic Deuteranopia (D-type), and three persons with Anomalous Trichromatic Deuteranomaly (Da-type).

The differences in the results between the P-type and the Pa-type, and the differences in the results between the D-type and the Da-type were small. Therefore, we analyzed them as the P_Pa-type and the D_Da-type, respectively. The results showed that regardless of the color vision characteristics, perceived whiteness was evaluated as being low for stimuli with hues ranging from green to yellow-green. The results of the P_Pa-type and the D_Da-type observers were similar, and significant differences were observed only for 3G and 4YR stimuli. However, significant differences were observed in the evaluation results between the N-type and the color deficient observers regarding eight stimuli. Overall, the P_Pa-type and the D_Da-type observers had a tendency to evaluate perceived whiteness as being lower for the stimuli ranging from reddish hue to yellowish hue, including the long-wavelength component, compared to the N-type observers. This was thought to be caused from the P_Pa-type and the D_Da-type observers having lower sensitivity in long-wavelength for brightness perception compared to the N-type observers. In addition, the P_Pa-type and the D_Da-type observers evaluated that the perceived whiteness was almost the same level as the greenish and reddish stimuli along the color confusion locus. The interobserver variability of the color deficient observers was smaller than that of the N-type observers. This might be due to the N-type observers having the individual internal criteria when evaluating reddish-white or greenish-white as being whiter.

PS1-69

An Experiment of Color Rendering with 3D Objects

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ABSTRACT

The Color Rendering Index was developed by CIE in order to measure how accurate a light source is at reproducing the color appearance of the lighted scene. This index has been used for many years by research and industry. Unfortunately this index tends to fail the scoring of the new LED-based lighting systems, as demonstrated by many experiments.

Many attempts to develop a more reliable index have been done, but a definitive method has not been found yet. In developing alternative color rendering indices, the goal is to have an index able to help in choosing a light source, maximizing the perceived quality of its color appearance reproduction. An index with a very high or a very low score is easy to interpret, but the goal is to have a color-rendering index able to scale changes in color shift proportional to our vision between the two extremes.

One aspect not enough investigated in literature, is the influence of the characteristics of the observed scene in the color appearance preservation under varying illuminants. The presented work aims at investigating appearance variation of real non-flat objects under varying illuminants. Here we present an experiment to assess the color appearance preservation of 3D objects illuminated by different light sources, according to human sensation. During the experiment participants has to compare a set of color samples observed under a reference light source and under a test light source. Participants' answers are recorded through a questionnaire. The use of 3D scene has the peculiarity to

introduce shadows and inter-reflections, created by complex geometries, reproducing everyday scenes. Finally the results are compared with a set of alternative color rendering indices recently developed.

PS1-70

Adapting and Adapted Colors under Colored Illumination

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ABSTRACT

Simultaneous color contrast and chromatic induction are well known color appearance phenomena. The color appearance of a test patch surrounded by a colored field changes depending on the color of the surrounding. For example an achromatic patch appears achromatic when it is presented alone but it becomes slightly greenish when it is surrounded by a red surrounding. The change of color appearance of the test patch is much enhanced if the experiment is done by two rooms technique or surrounding-stimulus independent illumination technique in which a subject room and a test room are used with a window, large or small, between the two rooms. An achromatic test patch placed in the test room illuminated white and filling the window appears very vivid greenish blue when the subject room is illuminated by red light.

The color of illumination is called the adapting color and the color of test patch is called the adapted color. By knowing the relationship between the adapting color and the adapted color the state of the visual system when it is adapted to color illumination. In this experiment four seven colors covering hue were employed for the subject room at 50 lx and white light was used for the test room at 9 lx. The window size was 40 cm wide and 30 cm high. Subject judged the color of the achromatic test patch by the elementary color naming method. It was found that the adapted color was not necessary the opponent color to the illumination color in the subject room. Data to give the adapting and adapted color were collected from papers of other researchers and plotted together with the present results in a graph of the adapting color versus the adapted color. The relation was exhibited by a sine curve and the opponent color relation between the adapting color and the adapted color was found only for one pair of the colors, approximately G70Y and R70B when expressed by NCS notation system.

PS1-71

Color Constancy Depends on Initial Visual Information

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ABSTRACT

When a subject looks at a white board in the test room illuminated white and low through a wide window opened on a separating wall between the test room and the subject room illuminated high by a colored light the window appears a very vivid colored paper of which color is opposite to the illumination color of the subject room if there is no objects in the test room beside the white board. If an object is introduced in front of the white board the subject recognizes the test room and the white board with a slightly desaturated color to imply that he now can perceive the existence of the test room and the color constancy starts to take place. The object introduced in the test room is to help the subject to recognize the test room and get the color constancy and it is called the initial visual information IVI.

In this experiment the complication of the IVI was increased gradually from just one piece of a flower petal to finally several flowers and leaves and the color of the white board was measured by the elementary color naming method. The test room was kept at 0.5, 1, 3 and 9 lx and the subject room at 50 lx. Five subjects participated in the experiment. Four colors of illumination in the subject room, red, yellow, green, and blue were employed. The color of the white board started with a vivid color with simple IVI and gradually desaturated to appear almost white as the increase of the complication of IVI. All the four colors of the subject room illumination gave a similar change of the color of the white board for the increase of IVI. It was found that the human visual system is very sensitive to IVI for the

construction of space recognition. Even a piece of petal already helped the subject for the construction.

PS1-72

Neighboring Color Effect on the Perception of Textile Colors

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ABSTRACT

Color is an attribute of visual sensation perceived in the context of various factors such as background, shape, size, surface property, and illumination geometry. In this study, the effect of neighboring color on color perception in textiles was investigated using three primary colors, cyan, magenta, and yellow, placed with twenty different neighboring colors. Totally 243 woven samples were constructed in 1/4 sateen weaves among which three are reference samples, i.e. 100% primary colors, and 240 are test samples, i.e. primary/neighboring color combinations in the proportions of 1:4, 2:3, 3:2, and 4:1. Off-white yarns (L* = 92.97; a* = -0.46; b* = 1.58) were used for warp, and cyan (L* = 50.48; a* = -19.76; b* = -38.14), magenta (L* = 51.20; a* = 62.45; b* = 0.86), and yellow (L* = 84.87; a* = -0.60; b* = 88.37) yarns were used for weft in varying proportions so that woven colors are varied in L*, C*, and h˚ values. The changes in color appearance of cyan, magenta, and yellow caused by the presence of a neighboring color were visually assessed by 12 normal color-vision observers using a magnitude estimation method under the Verivide D65 simulator. For the visual assessments, the three primary colors were physically measured first by a Konica Minolta CS-2000 spectroradiometer. Based on the measured data, observers assigned a reasonable number to describe the lightness (0~100), colorfulness (0~no top limit), and hue (0~100% of predominant psychological primaries which was then converted into 0~360˚) of each primary color in test samples by comparing them with reference samples. The results indicate that: (i) each primary color has the different color attribute most affected by neighboring colors, i.e. lightness for magenta, colorfulness for yellow, and hue for cyan; (ii) in terms of overall color, cyan was perceived most differently from its actual, i.e. physically measured, color under the influence of neighboring colors; and (iii) these neighboring color effects generally become more apparent and varied with an increment in the size of the neighboring colors.

PS1-73

The Impact of Light at the Perception of Colours in Architecture State of the Art Study and Suggestions for Further Research

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ABSTRACT

This paper presents results of the state of the art study carried out at Light & Colour Group at NTNU in 2014. The aim of this study was to present an overview of contemporary research dealing with the impact of natural light, sometimes modified by different glazing types, at the perception of colours in architecture. This was considered as necessary for identifying areas that are missing from the research map of this topic. Based on this study, suggestions for future research were formulated.

The current development in the glass and glazing technologies results with new products, e.g. windows, glass-façade or glass roof elements e.g. with high-tech coatings on the glass. Increasingly often they have chromatic features that influence the spectral power distribution of the light passing through them. We may compare many modern glazing products to a colour filters situated in the building envelope openings. Such filters may change the perception of colours in interiors and the perception of outdoor colours observed through the "filter-glazing". A colour shift of surface colours may occur. Also one of the crucial aesthetic issues in architecture, namely the visual appearance of building facades, depends considerably on the optical qualities of the glazing.

About 100 papers were found in: Science Direct, Scopus, Sage and Wiley online library using the following keywords: Light, Coloured light, Colour, Vision, Colour shift, Colour temperature,

Visual perception, Window Glazing, Transmittance, Spectral composition, Visual comfort and Smart window.

As expected, numerous papers deal with light and colour at the general level. The most interesting founding is that a considerably large number of papers, especially from the last 10 years, present studies of a new generation of dynamically responsive glazing called "smart windows". Smart window notion comprise different glazing technologies that can be reversibly switched from a closed to a transparent state resulting in thermal and optical properties that can be dynamically controlled (Lee et al., 2004). One example of smart window technology is the electro-chromic (EC) glazing which is controlled by a small applied voltage. In the closed state the EC glazing has a very strong chromatic feature, e.g. a dark blue colour. Most of the reported studies examined the effect of switchable glazing on visual and thermal comfort, but very little has been found regarding the effect of different types of smart windows on the colour shift, and consequently for visual environment.

The state of the art study aided us to formulation of the main research question for the future research in the Light & Colour Group:

What will be the consequences of using smart window technology for indoor and outdoor visual environment?

PS1-74

Evaluation of Cloth Roughness and Smoothness by Visual and Tactile Perceptions: Investigation of Cloth Photography Method for Online Shopping

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ABSTRACT

The purposes of this study are to clarify the evaluation criteria for cloth texture, particularly the cloth roughness or smoothness, by using visual and tactile sensations, and to investigate the method used for producing cloth photographs for online shopping websites such that observers can determine the degree of "roughness" or "smoothness" of the cloth by using the evaluation results.

In our previous research, to investigate an observer's accuracy of identification based on his/her visual and/or tactile response to both an actual piece of cloth and a photograph of the same, two fabric identification experiments were conducted. These experiments involved the participants' performing: 1) blind touch identification of an actual piece of test cloth after they observed a photograph of the same and 2) visual identification of an actual piece of cloth while they reviewed a photograph of the same. The results indicated that even if an actual piece of cloth and a high-quality photograph are presented to the observers, some types of cloth are identified at a low rate. Therefore, there are considerable disagreements between capturing the actual conditions of a piece of cloth and evaluating a photograph of the cloth. Although the latter evaluation method is mostly established in the field of psychophysiology, the former photography method is largely based on the photographer's capability. If the photography conditions corresponding to the evaluation result of the cloth texture are clarified, many types of cloth will be identified at a high rate. Further, another previous study clarified that the terms "roughness" and "smoothness" are important words for evaluating cloth texture.

Therefore, a method to photograph a piece of cloth that can make it easy to evaluate cloth texture in terms of "roughness" or "smoothness," was investigated in this study to realize an accurate online shopping experience. In particular, two evaluation experiments were conducted. One was a visual evaluation (VE), in which the surface texture of an actual piece of cloth was evaluated solely by visual perception. The other was a visual and tactile evaluation (VTE), in which cloth textures were evaluated by using both visual and tactile perceptions. Evaluation characteristics of "roughness" and "smoothness" were examined in each experiment. The results showed that many types of cloth were overestimated for "roughness" when VTE was conducted and underestimated for "smoothness" when VE was conducted.

Another experiment was conducted for evaluating surface textures using photographs of pieces

of cloth shot at different distances between the cloth and the digital camera.

Object distances that showed the same or similar evaluation results were examined and clarified using VE and VTE of the photographs. Thus, we confirmed that the studied method can be used for taking cloth photographs, which observers can determine the degree of "roughness" or "smoothness" of the cloth, for online shopping websites.

PS1-75

Study of Color Preferences of Gac Fruit Blended with Mixed Mushroom Juice

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ABSTRACT

Color is an important physical properties that are find in all foods provide an acceptable quality of purchasing decisions of consumers, especially in fruits and vegetables. The color of an object depends on both the physics of the object in its environment and the characteristics of the perceiving eye and brain. Physically, objects can be said to have the color of the light leaving their surfaces, which normally depends on the spectrum of the incident illumination and the reflectance properties of the surface, as well as potentially on the angles of illumination and viewing. Thailand has a lot of fruit and vegetable throughout the season. Mushrooms are example of a low-calorie food source (higher than 20% of the Daily Value, DV) of B vitamins, such as riboflavin, niacin and pantothenic acid, an excellent source of the essential minerals, selenium (37% DV) and copper (25% DV), and a good source (10-19% DV) of phosphorus and potassium. Fat, carbohydrate and calorie content are low, with absence of vitamin C and sodium. The advantages of mushroom extracts are studied as possible treatments for diseases, such as cardiovascular disorders. Some mushroom materials, including polysaccharides, glycoproteins and proteoglycans are under basic research for their potential to modulate immune system responses and inhibit tumor growth, whereas other isolates show potential antiviral, antibacterial, antiparasitic, anti-inflammatory, and antidiabetic properties in preliminary studies. Currently, several extracts have widespread use in Japan, Korea and China, as adjuncts to radiation treatments and chemotherapy, even though clinical evidence of efficacy in humans has not been confirmed. Gac fruits or Momordica cochinchinensis is a Southeast Asian fruit find throughout the region from Southern China to Northeastern Australia, including Thailand, Laos, Myanmar, Cambodia and Vietnam.. The advantages of lycopene are anti-oxidant very strong and contributed significantly to inhibit the growth of cancer cells. The objective of this research was to study color of gac fruit blended with mixed mushrooms juice affected on consumption acceptabilities. Firstly, to study an appropriate ratio of gac fruit and three types of mushroom (Shitake, Golden and Angel) juice by using bael as taste additive. After that, blending of aliquots were performed homogeneous with an electric blender. Colors measurement of all treatments were tested by using Hunter Lab Instrument. The results found that trends of higher amount of gac fruit and mixed mushroom provided dark red. Finally, Sensory evaluation of panelists were revealed that gave acceptability data to represent overall of panelists. From the information above can be used in developing color of products in form of health drinks, covers the essential nutrients and essential bioactives needed in the future to meet the demands of consumers, which has increased steadily and expanded, in the large level in beverage industry.

PS1-76

Luminance Contrast of Thai Letters Influencing Elderly Vision

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ABSTRACT

In this research, we investigated the effect of luminance contrast between text and background on legibility of Thai letters. Three groups of subjects participated in this research. The first group was 30 of young students (age between 18-23 years old) who had normal or corrected-to-normal visual acuity. The second group was the same 30 subjects from the first groups. They were asked to wear cataract experiencing goggle in order to simulate vision of the elderly during the experiment. We named the second group as the simulated elderly. The third group was ten of real elderly (age between 58-66 years old). All subjects had normal color vision. The stimulus configuration was a row of ten random Thai letters presented on an LED display. The letter's size was 0.35 degree at 246 cm viewing distance. The luminance contrast between text and background was composed of five levels of positive polarity and five levels of negative polarity. The subjects viewed the stimuli in a room which illuminated at 0 and 300 lux. The first task of each subject was to report those 10 random letters. Reading performance was calculated in %correct answer. For the second task, the subjects was asked to rate the reading easiness of those letters. The two tasks were conducted in separated sessions. The results showed that for positive polarity, reading performance and easiness score of the real elderly were slightly lower than those of the other two groups. For negative polarity, result of the real elderly under 0 and 300 lux was slightly different. However, at low luminance contrast, reading performance and easiness scorer of the young under 300 lux was suddenly declined and significantly different from reading performance under 0 lux. The required luminance contrast between text and background for the elderly had to be higher than the required luminance contrast of those two groups.

PS1-77

Color Rendering Analysis Based on Color Pair Evaluation under Different LED Lighting Conditions

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ABSTRACT

Color rendering is the effect of an illuminant to be tested on the color appearance of objects by conscious or subconscious comparison with their color appearance under a reference illuminant. Color rendering index have been developed as many different versions by related researchers. The CIE color rendering index (CIE-CRI) is the most widely used measure for quantifying and comparing the color rendering performance of light sources. However, several other color rendering measures, including CQS and CAM02UCS-CRI, are also being discussed in some specific fields such as estimating the color rendering of an illuminant for the purposes of preference color, natural color, or bigger color gamut.

Most color rendering measures are concentrated on the precise rendering of a single color under the test illuminant comparing with the standard illuminant, and few studies estimate an illuminant by the rule of the color difference between color pairs. Hereby, this study focuses on the color discrimination of two colors under individual illuminants. Based on the psychophysical method of gray scale, a visual experiment was carried out to test the effects of LED lightings on the color discrimination of color pairs with Munsell color samples. A panel of 10 observers participated in the color discrimination evaluations under 12 lighting conditions, including 2 levels of illuminance and 6 correlated color temperatures (CCTs) ranged from 2000K to 10000K in a LED lighting booth. All the Munsell color samples were classified into 16 groups and each group involved a reference color sample and several test color samples. In every sample group, the color differences between the reference color and the test colors were either hue differences or value (lightness) differences or chroma differences.

The experimental results demonstrated that the illuminant had obvious impacts on the perception of color differences, and the effects were different for the color pairs with the differences of hue, lightness or chroma. Moreover, it is very difficult to assess the color difference of the colors with high lightness, such as yellow, under all lighting conditions even if their color differences between

the reference and test colors are relatively great. A correlation analysis was implemented between the perception of color difference and the different color rendering measures of CIE-CRI, CQS, and CAM02UCS-CRI, which indicated that the degree of correlation depended on the type, i.e. hue difference, lightness difference or chroma difference, of color difference of the color pairs. Therefore, it needs to be also considered to involve the color difference evaluation of color pairs under different LED lighting conditions for the development of the new color rendering index.

PS1-78

The Relationship between Whiteness Perception of Watercolor Illusions and Color Vision Characteristics

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ABSTRACT

When the inner and outer outlines of shapes are painted with two colors, the inner color appears to spread out. This phenomenon is called a 'watercolor illusion'. In previous studies, we clarified that the combinations of outline colors that increase the perceptual whiteness of a watercolor illusion figure were blue (inner outline color) – yellow (outer outline color), red (inner outline color) – green (outer outline color), and blue (inner outline color) – green (outer outline color). Furthermore, we allocated the outer outline color of the watercolor illusion figure on both sides of an inner white color to configure ground colors. We then lapped the horizontal stripes of the inner outline color over the ground colors so as to create a new stimulus. We investigated the whiteness perception using the new stimulus. We then clarified that the whiteness perception is almost the same for both the watercolor illusion figure and the horizontal stripe pattern. However, these findings were from subjects with normal color vision and we did not touch upon the whiteness perception of subjects with color vision deficiency. In this study, we investigated the difference of whiteness perception caused by the color vision characteristics using the watercolor illusion figure and the horizontal stripe pattern.

The subjects consisted of 12 participants with normal color vision (N-type), six participants with Dichromatic Protanopia (P-type), and eight participants with dichromatic Deuteranopia (D-type). The watercolor illusion figure and the horizontal stripe pattern were used as stimuli. The combinations of colors were blue (inner outline color of the watercolor illusion figure, figure color of the horizontal stripe pattern) – yellow (outer outline color of the watercolor illusion figure, ground color of the horizontal stripe pattern), yellow (inner, figure) - blue (outer, ground), red (inner, figure) – green (outer, ground), green (inner, figure) – red (outer, ground), blue (inner, figure) – green (outer, ground) and green (inner, figure) – blue (outer, ground). The subjects compared the whiteness between the blue – yellow and the yellow – blue color combinations, between the red – green and the green – red color combinations, and between the blue – green and the green – blue color combinations.

From the experimental results, any clear difference of the whiteness perception between the watercolor illusion figure and the horizontal stripe pattern was not observed. Twenty three out of all 26 subjects reported seeing either "white","clear white"and "vivid white" for the blue (inner, figure) – yellow (outer, ground) color combination. No difference was observed on the whiteness perception between the N-type and the color vision deficiency subjects for this color combination. However, for the red (inner, figure) – green (outer, ground) combination, the majority of the P-type subjects gave answers of "white", "vivid white" and "brilliant white". The majority of the D-type subjects gave answers of "bright white", "beautiful white" and "white" for the green (inner, figure) – red (outer, ground) combination. For the green (inner, figure) – blue (outer, ground) combination, the majority of the N-type subjects gave answers of "dull white", "yellowish white" and "cloudy white" but the color vision deficiency subjects did not give a similar response.

PS1-79

Influence of Daylight Illumination in the Visual Saliency Map of Color Scenes.

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ABSTRACT

Visual saliency maps code topographically local conspicuity over the entire scene. They are based on image properties such as color, luminance or orientation. Studies in humans have shown that color can influence visual attention but only few studies concentrate on this issue [H.-P. Frey et al, Journal of Vision, 8(14):6, 1–17 (2008); Amano and Foster, J. Opt. Soc. Am. A31, 4, 254-262 (2014)]. And because object colors depend on both the spectral reflectance of the surfaces and the spectral power distribution (SPD) of the light impinging on them it is plausible to check also the influence of that SPD on the saliency maps of color images. We used a set of natural and artificial images, which were decomposed into their Luminance (Lum), Red-Green (RG) and Blue-Yellow (BY) channels and were classified according to their semantic content. Images were simulated under daylights with Correlated Color Temperatures (CCT) from 2,735K to 25,889K and the saliency maps for each channel were computed using the Itti-Koch saliency algorithm implemented by J. Harel [http://www.klab.caltech.edu/~harel/share/gbvs.php]. Preliminary results suggest low differences among the saliency maps under different daylight CCTs, being minimum and maximum along the RG and Lum channels, respectively.

PS1-80

Comparison between Multispectral Imaging Colors of Single Yarns and Spectrophotometric Colors of Corresponding Yarn Swatches

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ABSTRACT

The state-of-the-art multispectral imaging system can directly acquire the color of a single yarn that is impossible for traditional spectrophotometers. Instead, single yarns are winded on a background card to constitute yarn swatch, which spectrophotometric color is regarded as the yarn color and is utilized to color matching and color reproduction in textile. While colors of single yarns and corresponding yarn swatches can be separately acquired by multispectral imaging systems and spectrophotometers, comparison between single yarn color and yarn swatch color acquired by these two types of instruments is not yet well investigated. This paper comparatively studies the multispectral imaging colors of single yarns and spectrophotometric colors of corresponding yarn swatches using 100 pairs of single yarn and yarn swatch samples. The colors of the yarn swatch samples were measured by a desktop spectrophotometer Datacolor 650. The colors of the single yarn samples were acquired by a multispectral imaging system, namely Imaging Colour Measurement (ICM). A single yarn was segmented from the background by an image difference method and its multispectral imaging reflectance was specified as the average reflectance of all the pixels on it. Lightness (L*), hue (a* and b*), as well as color difference between the multispectral imaging colors of single yarns and spectrophotometric colors of corresponding yarn swatches were detailed analyzed. Experimental results show the following: 1) the lightness of a single yarn measured by ICM approximates 0.91, 0.91, and 0.90 times that of the corresponding yarn swatch measured by spectrophotometer under the CIE Standard Illuminants D65, F2, and illuminant A; 2) a single yarn measured by ICM is 0.88 times a* value of the corresponding yarn swatch measured by spectrophotometer under D65, F2, and illuminant A; 3) the b* attribute of a single yarn measured by ICM approximates 0.91, 0.91, and 0.90 times as large as that of the corresponding yarn swatch measured by spectrophotometer under D65, F2, and illuminant A; 4) the mean color difference between the single yarns measured by ICM and the yarn swatches measured by Datacolor 650 under 9 CIE Standard Illuminants (Illuminant A, Illuminant C, D50, D55, D65, D75, F2, F7, and F11) is 2.79 CMC(2:1) units.

PS1-81

New Color Rendering Index Based on Color Discriminability and Its Application to Evaluate Comfortability of Illuminants

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ABSTRACT

One of the problems on the CIE CRI (Color Rendering Index) is that it is a relative evaluation of illuminants to the standard illuminants. Standard illuminants having too low or too high correlated color temperature may not suitable for real situation but they are always evaluated as Ra=100. Another problem is that the CIE CRI of such illuminant cannot be calculated as when correlated color temperature is not available as its color locates far away from Planckian locus in the chromaticity diagram.

We proposed a new way of evaluating color rendering performance based on color discriminability. We conducted the experiment based on Munsell 100 hue test, in that number of hue is increased to 180, and performed color discrimination task under various illuminants having various spectra. We found that maximum errors of the task under various illuminants are correlated with a minimum color difference among 8 TCSs (Test Color Samples used for the CIE CRI evaluation) when they are plotted on the CIELUV uniform color space under each illuminant. We called this index CDC (Color Discriminability Criterion) as color discriminability is improved as CDC increases. CDC can be calculated without standard illuminants and applicable for all illuminants even when their color locate far away from Planckian locus.

In the above experiment, there was a tendency that illuminants having lager CDC seem more comfortable because color chips appear more colorful under such illuminants. So, we conducted another experiment to evaluate comfortability of illuminants using semantic differential method. The results show that such illuminants are not necessarily comfortable as when CDCs are large. Subjects felt uncomfortable under certain illuminants, though they have large CDC, because red colors appear too prominent. Spectra of such illuminants are unbalanced as some spectrum region is too low and another region is too high. We introduced another index, that is the minimum lightness (L*) value among 8 TCSs under a test illuminant, to evaluate balance of the spectrum. The index is called CL (Critical Lightness) because lack of energy in certain spectrum region can be improved by making CL larger. We found that one feels more comfortable under such illuminants that have lager CDC and lager CL.

PS1-82

Color Monitoring Method under High Temperature during Oven Cooking

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ABSTRACT

For food processing such as heating and baking, oven is one of the most popular appliances in both of industry and domestic households. In general, the temperature of the oven chamber is monitored and regulated automatically during in the process. In this case, the automated cooking is performed using programmatic control method. That is, only time and temperature are used and color information is not used. In contrast, when the food is cooked manually (i.e. with a frying pan), we tend to monitor food's appearance visually and judge whether it is done or not using its color as a clue without measuring time and temperature. This is because the appearance monitoring in real time, that is, in-situ color measurement, has the advantages of making it possible to optimize the food's appearance and to provide delicious-looking foods. The appearance is one of the most important factors for food consumers.

For these reasons, we have developed color monitoring equipment and a method for oven cooking during heating. In our previous study, we reported the in-situ color monitoring method that

a halogen light, an optical fiber and a spectrometer have been used as a light source and a measuring instrument, respectively. Three types of food materials were also used as samples: toast (sliced white bread), a plain cookie, and raw chicken meat pate. Then, prediction expressions for the change in chroma and lightness (quantitative attributes) of the food surface during oven baking were developed based on experimental data.

In this study, we investigate the real time monitoring method using charge-coupled device (CCD) camera as a color detector. We develop an experimental small oven and examine this monitoring method under a temperature of over 200°C. The cooking and the prediction expressions which have reported previously are also used. For considering practical usage, infrared heaters installed in commercial oven (100V-600W-2000K) are used as light source. The experimental results demonstrate their applicability for this purpose. Suitable methods for automatically determining the optimal conditions considering the preferences of users are also proposed.

PS1-83

Woodblock Printing as a Means for 2.5D and 3D Surface Evaluation

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ABSTRACT

Inspired by traditional Chiaroscuro woodblock printing techniques of the 16th century, we explore the use of multicolour impressions produced by relief prints as a means to evaluate the surface rendered with 2.5D and 3D printing technologies. Even though topography and micro-imaging methods can be used to measure surfaces, perceptual quality evaluation from surfaces rendered by additive printing methods is still a challenge. By reducing the dimension from 3D or 2.5D back to 2D, classic methods to measure quality that have already found a correlation with human perception would become available to us.

A traditional relief print is created through the combination of a raised printing surface and the surface qualities of the printing block (end-grain hardwood, chipboard, linoleum, acrylic), which is then inked and printed under great downward pressure. The block surface is manipulated by engraving, cutting and abrasion (traditional tools include sharp V shape or U shaped chisels). In order to obtain a high quality printed image, the inked plate needs to produce a solid and well defined line with uniform colour.

As a benchmark of our idea, we employed different methods to control the modulation of a surface by either carving (laser cutting, CNC engraving) from an existing material (acrylic, wood, model board) or building relief using additive fabrication (Makerbot, Océ 2.5D printer prototype). For print analysis we created a set of two targets generated to test special resolution and edge detail. Following traditional printmaking processes the blocks were inked, and subjected to a high level of downward pressure in a press to create impressions (i.e. the surface is embossed by the physical force). All of the blocks were inked and printed in the same way. Instead of evaluating the quality of the surface rendered by each of the methods directly, we perform the evaluation on the impressions made with the blocks.

Each of the testing blocks was adapted from optical frequency test patterns in order to access special resolution and edge detail in print. The first test target uses the 1951 USAF resolution test chart where groups of three horizontal and vertical lines, referred to as elements, are depicted at varying sizes and orientations. By finding the element with the smallest discernible set of lines, we can indicate the resolution corresponding to a given printing block fabrication method. For the second target we utilised a Zone plate ring pattern with a special frequency up to 2 line pairs per millimeter (LP/mm). Different aspects can be assessed on the impressions such as the density of ink, the uniformity of the surfaces, the sharpness of the edges and the spatial resolution at different angles. For instance, the Modulation Transfer Function (MTF) describing the print accuracy for different frequencies in horizontal, vertical and diagonal directions can be found for each of the methods based on the impressions.

In our paper, we discuss the results of our method with each of the available technologies and the possible extension of our solution for the evaluation of more complex features.

PS1-84

The Relationships between Colors of Neck, Cheek, and Shaded Face Line Affects Beauty of Made-up Face

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ABSTRACT

To choice color of make-up foundations aimed at beautiful finish are difficult for many users. For this subject, to acquire knowledge of psychological processes for evaluating beauty is important. On the basis of this knowledge, the quantitative evaluation method could be developed using photographs of faces and image analysis technology or other color analysis technology. And then, this method could provide effective advices for users feeling difficulty in the color choices. In this study, the visual evaluation of beauty was conducted by 34 participants using 40 photographs of 4 female faces applied 10 make-up foundations having individual colors. These colors were designed to change colors of faces to various color directions (bright-dark, red-yellow, etc.) on the basis of the colors of their bare faces. And then, the image analysis were conducted to find the factor relating with results of this visual evaluation. As a result, the index value indicating the dissociation degree of 2 color directions had a strong negative correlation with scores of the visual evaluation. These color directions were calculated by plotting L*a*b* values on the arbitrary line from neck to cheek using image analysis. One of the color directions was set up as the direction from the color of the region of face line to the color of the region of neck. The other one was set up as the direction from the color of the region of face line to the color of the region of cheek where was the lower region in cheek. In fact, the more these color directions accorded, the higher these scores of beauty became, and the more these color directions dissociated, the lower these scores became. This result suggested that participants of the visual evaluation used this dissociation degree to evaluate beauty, and one of the main factor of beauty about faces applied make-up foundations was the feeling of strangeness by this dissociation. On the other hand, most of the bare faces get high index value of this dissociation. However, bare faces do not cause the feeling of strangeness which is similar to the feeling caused by faces applied make-up foundations having mismatched color. This fact indicates that psychological processes for evaluating beauty of bare faces and made-up faces are different. We discuss this specific process of made-up faces with these results and the result of the experiment using visual simulation.

PS1-85

Experimental Method Suggested for Optical Observation of Anisotropic Scattering

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ABSTRACT

Authors suggest some experimental methods to observe optical anisotropy of materials inducing impression in human sense.

Glossy or glaring materials (fibers, textiles, jewels,,etc) generally show anisotropic or discrete reflection as passive light scattering. However, usual method using a goniometer to observe scattering intensity is not effective to estimate anisotropic distribution of beams scattered to surrounds.

Suggested method is experimental layout to measure anisotropic reflection under irradiation by external incident rays; scattered lights from a sample irradiated by straight beam are projected on some surface with controlled shapes, such as parabolic or ellipsoidal surface. Projection or reflection at the surface can be analyzed as 2-dimensional images observed at particular position.

Through imaging analysis, distribution of scattering in wide angle range can be estimated numerically and rapidly.

PS1-86

Color Measurement of Meat in Cooking under LED Lightings with Different Spectral Distributions

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ABSTRACT

Color appearance of meat when cooking is important in order to confirm how it has been cooked. Color depends on the lighting condition such as the illuminance and the spectral power distribution. This study aims to measure the color of the meat when cooking under several LED lightings with the different spectral power distribution.

First, we prepared three kinds of minced meat, beef, chicken and pork, and shaped these meats into a cube, 2 cm on a side. Each cube of the minced meat was baked with an electric oven at the temperature of 200 degrees Celsius. We set 22 stages as the cooking time; using thirty seconds intervals till five minutes, one minute intervals from five till ten minutes, two minutes intervals from ten till twenty minutes and five minutes intervals from twenty till thirty minutes. We put each cube into an integrating sphere with a diameter of 60 cm. Next, we measured the average chromaticity of each cube in at the raw stage and at the 22 stages of the cooking time above mentioned, using a two-dimensional luminance colorimeter (UA1000A, Topcon Co. Ltd.) under eight lighting conditions; standard illuminant D65 and seven kinds of LED lighting conditions which differed in the correlated color temperature, the color rendering index and spectral power distribution. These LED lighting consisted of three types of white LED and RGB LED.

According to the results of the minced beef under D65 lighting condition, L^* value was 49.5, u' value was 0.300, v' value was 0.494 when it was raw. At the stage of ten minutes cooking time, L^* value was 43.7, u' value was 0.230, v' value was 0.490. At the stage of thirty minutes, L^* value was 33.5, u' value was 0.236, v' value was 0.481. Under 4000K white LED, L^* value was 40.7, u' value was 0.337, v' value was 0.503 when it was raw. At the stage of ten minutes cooking time, L^* value was 37.3, u' value was 0.256, v' value was 0.501. At the stage of thirty minutes, L^* value was 31.9, u' value was 0.247, v' value was 0.492. We achieved color measurement of a meat when cooking, and indicated that the color change done by cooking is systematically different and depends on the lighting conditions.

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PS1-87

Color Temperature and Illuminance of Main Streets with Day and Night Illumination in the Center of Osaka, Japan

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ABSTRACT

Nowadays with an aim of creating comfortable, delightful and interesting urban environment, various factors in the actual environment are used to promote attractive plans. There are many topics on the beauty of the scenery concerning color planning. In color planning, surveys obtained not only from the surface color but also lighting planning are very important.

The author considers it is very important to designate lighting planning for urban color planning.

This paper includes a survey concerning lighting atmospheres of the urban districts and questionnaires in Osaka City. The author obtained data from 2 main sources: 1)measurement data on daylight and night illumination. 2) questionnaires obtained from young people in Osaka.

. Firstly two downtowns were selected to decide measurement point, one was northern and the other southern in the center of Osaka City. 5 streets had been picked up in each downtown and 16 measurement points were chosen on each street with 20 meter interval. In every point was measured the value of horizontal and vertical Illuminance, horizontal and vertical chromaticities on daylight and night illumination respectively during three days.

Questionnaires were carried to find any difference in psychological perceptions relating to lighting on these streets. The subjects were all students in their twenties and had visited those streets on the day and night.

As a result of the survey, the mean value of illuminance on every street was same considerably at night but not daytime, and that of chromaticities were not shown differently comparing to illmimannce. The result from questionnaires had shown the street lighting was effective in making people feel bright and safe.

The conclusions will not be enough to implemented, however the author can recommended how to improve illumination on the street and how to change them to achieve a better visual impact and perception.

PS2-1

Changes of Color Names and Coloring Materials in Japan

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ABSTRACT

The color of Japan had several conversions historically, and at least three conversions exist.

The first conversion is introduction of the color notion in 6th century. Before that, a few natural dyes and mineral pigments were already used in Japan. Because of the lack of the historical materials, the actual circumstance of formation and classification about color names are not clear. Around the 6th century, by trade with the China (such as the Tang dynasty) and the countries of Korean Peninsula, “Saishiki(coloring)”, the manufacture of pigments, the notion of color like “Goshiki(5 colors)” were conveyed to Japan. After that, various color names appeared in Japan. Through the works of art and the historical materials of the 8th century, we can see the development of color materials and color names.

The second conversion took place in Heian period. The abolition of official envoys to Tang dynasty, and the imitation of the Chinese Tang culture were over at the end of 9th century. After 10th century, enhancement of the Japanese culture led to the development of literature, dresses and their ornaments at salon culture in the Court. In this time, new color “Kasane” was created in dresses. It describes the colors which layered or put in order and likened the color to the plants or the natural phenomenon. This “new color” was not the discovery or development of new coloring materials and dyes. Moreover, the skill and knowledge of the dye plant cultivation which continued from Asuka and Nara period had begun to be lost gradually. From this time, some colors even if they were made of another color materials had been called as the same color names.

The third conversion is change of the coloring materials. In Europe, synthetic dyes was developed in the 19th century, and the “painting” changed. In Japan, at the Meiji Restoration, “Westernization” was called for. Then the inflow of techniques and materials of oil painting and watercolor painting took place. Furthermore it brought about change of the coloring materials of Japanese fine arts and traditional handicrafts. Simultaneously, the color theory developed in Europe and America was also brought to Japan. The color mixing and the three primary colors were studied immediately in Japan. Before inflow of synthetic dyes, coloring materials (most of mineral pigments) could not accomplish the expression of mixture of colors. However, by changing the coloring materials and studying of the color mixing and the three primary colors, colors were mixed and new colors were expressed at Japanese fine arts and crafts.

After passing through such changes, some “new” colors by synthetic dyes and imported coloring materials were come to be called by color names of “old” materials. Accordingly it has not been made abundantly clear whether or not the colors called as “the color of Japan” actually have Japanese traditional elements. Since the situation of such multistory changes are not researched, this research organize the historical conversion of “the color of Japan”, and it clarifies the background of color notion development of Japan.

PS2-2

Differences in the Drawings and the Color of the Violence in Children from Three Different Cultures.

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ABSTRACT

The violence is a social phenomenon, that, although it has been present in all the history of the human beings is not inherent to all the individuals, and it is known that the social environment contributes to its development.

The fear produced by the violence is intensified in the child population and that is why we considered important to know what the children think about the violence, how they perceive it and, if it is possible, how they feel it. We seek these answers through two media that are familiar and not dangerous for them: color and drawing.

Both are privileged elements for the research of violence through a visual image: drawing is a motor, spontaneous, coordinated and very complex activity that contributes to the formation of personality, and color is an element that stimulates the emotions, and, as a communicating element, informs about the emotional states through the analysis of the meanings and formation of chromatic patterns found in the drawings (Ortiz:2011). That is why we can say that humans live in a symbolic world of color, in which the meanings related to natural processes become social meanings and they form an important part of the culture where they emerge.

The research presented herein is oriented toward the investigation and the study of the way in which the children draw and color violent scenes, since their drawings will let us know their personal experiences.

Our objectives were:

- To know the influence of the native and urban cultures in the representation and use of colors of violence.

- To know the colors and the meanings that children from ten to twelve years use in their graphic representations of violence and not violence.

Population and sample:

The sample of the Mexican population was obtained from children living in Mexico City and in the States of Guerrero and Nayarit in native rural populations. The overall sample consisted of 20 children from Mexico City, 20 from Nayarit, and 20 from Guerrero.

Method

We used a qualitative method using rhetorical and semiotic analysis of the images for their interpretation.

Results

There are important differences in the use of color and the drawings in the three groups studied.

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PS2-3

Color and Image of the City in Environmental Design of Kazimir Malevich

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ABSTRACT

Kazimir Malevich is well known as a prominent painter. However, he also had a lot of interesting ideas about color environmental design, and his town-planning painting had a significant

impact on the color development of cities.

Malevich obviously realized that socialism changed not only the political system but also the ideology of people. It created new conditions for the development of color planning and urban color design, forced new ways for the production and distribution of color images in urban culture. His idea was that architects could not get rid of the existing architecture; however, they were able to use that accumulated architectural material as a basis for expressing new ideas and creating a new image of the city by means of color.

The article will consist of 5 parts.

The first part will demonstrate the ideas of Malevich on how color functions as an important symbol in environmental design and how a new color 'edition' helps to change the impressions about the existing social structure of urban society, and also serves as a means of promotion of some quarters, districts and even whole towns.

The second part will present the description of the main results of Malevich's experimental research into the role of color in the built environment. These studies will include the principles of color organization of the scenic architecture, the Architectons and Planits, Suprematism, facade coloration, and architectural painting of Malevich, implemented in 1919 in Vitebsk.

The third part will analyze the principles of form and space organization in Malevich's projects.

The fourth part will characterize the color structure, color constellations, and how they contribute to the creation of image and spatial illusion in the city.

An important aim of the fifth part will be the examination of the impact of unique methods (the phenomenon of "matrix", color-structuring of space, etc.) and ideas of Malevich (Architectons, Planits, Spatial Suprematism) on contemporary and subsequent architectural color usage. In particular, it will reveal the link between the work of Malevich and Russian avant-garde projects, especially to abstract axonometric compositions of geometric solids such as the Prouns of El Lissitzky. It also will show the ways in which the ideas on environmental color design of Malevich continue to exist in the modern popular culture of the city.

PS2-4

Comparative Study about Preference Tendency to Spatial Color Based on Color Recognitions and Emotions among Nations: Focused on Korean and Malaysia

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ABSTRACT

Recently, the Korean society, which was a single-raced nation, has been rapidly changed to the multi-national natured one caused by many immigrants from China, Southeast Asia, etc. and various social problems are expressed ostensibly. One of them is a difficulty suffered by children of the second generation from multi-cultural families who enter formal schools in Korea, which should be solved urgently at this time when it is predicted to be inevitable that globalization will be progressed in future as well. Only the understanding and acceptance of mutual cultural differences will be the solution to various problems caused at multi-cultural society. According to Linberg, color has superiority to the influences to human feelings and emotions and it is considered that the study about color preference and emotion comparison for the groups of mutually different cultures is worth of important data to understand characteristics of the nations and races. This study aims to understand the differences of preference tendency to colors at national recognitions and emotions about the spatial colors, by performing preferences and vocabulary appraisals targeted to the Korean and Malaysian students whose major is the design, and by targeting environmental colors applied to school health rooms which are changed to perform various functions for education, counseling, treatment, etc. in addition to the one just for temporary treatment in the past and which are required to perform a function for psychological and emotional stability at the same time.

This study also aims to understand characteristics among cultures by finding out differences of preference tendency to spatial colors and emotions among the nations whose cultures and regions are different. For the target and method of the study, ten school health rooms was selected among

the elementary schools located in Busan Metropolitan City and spatial colors were directly measured by using a spectrophotometer. They were taken pictures of spot. Based on the result from on-the-spot survey, the pallet for spatial colors and the spatial images were selected and the tools for questionnaire survey were written. Targeted to 80 Korean students and another 80 Malaysian who are very sensitive to use colors because their major is the design, the questionnaire survey was conducted and representative colors for each nation, preference to color pallet for spatial color for health room, and degree of emotions felt at the spatial image about health room were appraised. The emotional language used at the appraisal for emotion is IRI image language, which was extracted from by the experts, and frequency, cross analysis and confidence verification were progressed by the SPSS 12.0 application.

PS2-5

The Analysis of Door Color on the Traditional Palace of the Kingdom of Joseon

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ABSTRACT

This study is a part of the architectural element color analysis on the Traditional Palace(Gyeongbokguang, Changdeokgung and Changgyeonggung)of the Kingdom of Joseon. This study is based on door analysis on the Traditional Palace of the Kingdom of Joseon. In this paper, we adopt Munsell color system and NCS color system to study color usage on the door of the Traditional Palace.The purpose is to find out the color distribution range and the character on the doors and analyze the results based on cultural tradition of Korea. This study includes by three steps. The first was mainly for the study subjects'information searching work. This step used Color meter to color measurement of the door. Compared with other method, such as photo analysis method, this one raises precision and error is kept below 0.1.The second step was analysis on the subjects. In this step, this study used the Munsell color system and NCS color system to analyze the study subjects to get the color distribution range and the character of distribution range. The third step was to find out the reason based on cultural tradition of Korea by using the analysis consequences. The results are followings. Firstly, the range of door color distribution is from 5R to 10G. The range of door color distribution concentrated from 5R to 5YR by the Munsell Color system. And color adopted by door is low and middle value and chroma. Secondly, the color of door distributed in the range of 5 and 6. The character of the color in this area is dark, while the dark tones and dark tones correspond to nearly colorless. Lastly, the traditional palace color of the Kingdom is associated with traditional Korean culture. Korean traditional culture thinks that the relationship of person and nature should be a harmonious unity. The conclusion of this study is following. Under the influence of this idea, people prefer to use the natural unity of color and materials. The color of the palace also has the same character, the color impression is not serious and dignified sense. The impression is relaxed and stable integration of the natural feeling.

PS2-6

Comparison among Three Methods for Thai Colour Naming

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ABSTRACT

This research aims to locate Thai colour names in the Munsell colour system. Three different

experiments have been carried out: classical, categorized and online. For the first and second experiments, 10 and 20 subjects, respectively, were selected, half male and half female, having all normal colour vision. One thousand three hundred matt Munsell sheets were used in both experiments. From each Munsell sheet, a sample of 5 x 5 cm was cut for the first experiment and a sample of 2 x 2 cm was cut for the second experiment. The first experiment (classical colour naming) involved showing stimuli directly to each subject under controlled environment. Ten subjects were used in this experiment, 5 male and 5 female. The Munsell samples were placed on neutral grey background under simulated D65 light source in a standard light booth. The samples were shown randomly and the subjects were asked to express the name of each sample's colour as basic colour term or as non-basic colour term. Their response time was recorded for each colour sample. Two hundred colour samples were repeated twice to estimate naming consistency. The second experiment (categorize colour naming) was carried out on all 20 subjects. The Munsell samples were laid randomly on a grey background table with the size of 100 x 200 cm, under simulated D65 light source. The subjects were asked to categorize the colours of the samples according to the colour names they know. The process was repeated twice. In the third experiment, one hundred and fifty two subjects with 92% reporting normal colour vision named colour samples in an online colour naming experiment (Mylonas & MacDonald 2010). The mean age of all Thai participants was 33.4 (std = 10.2). Females were involved in 79% of the responses and males in 21%. Colour centroid, response time and consistency, obtained from all three experiments and from different languages, were compared.

PS2-7

A Study on Elements Perceived as Traditional among Fabrics and Colors for Hanbok

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ABSTRACT

After modernization, influenced by Westernization, hanbok, a traditional costume in Korea, is recognized as a uncomfortable and countrified costume. So Korean people is only wearing hanbok as event dress at big event like wedding or first-birthday party or 70th birthday. In this situation, many of hanbok designers are working for modernize and popularize hanbok through to the given a change in the design to modernized hanbok or life easy hanbok, or highlight of health and naturalistic point of natural dyeing and organic fabric cotton or linen etc. But hanbok is still have not been able to shake the perception of old-fashioned and countrified costume to the young people. So in this study, I feel the need for the development of hanbok color and fabric material for ways to modernize and popularize of hanbok, so that I plan to find out that they how to feel traditionally or modernly of which color or materials. So I make a hypothesis that if there are same colors or materials, have different levels of feel traditionally or modernly, according to materials or color. And for this study, I made 100 color chips used various fabric, for example cotton, satin, chiffon, organdy and fabric of really used hanbok in these days, and surveyed to 15 people in 20s and 30s of women graduate students .As a result, there was no big difference about color, brightness, colorfulness, but in material terms, I found difference that modern fabric materials are more limited than traditional fabric materials, as cotton, satin and fabric of really used hanbok. Therefore, that can be affected by the material than color to feel traditional of hanbok.Based on this, if the material of hanbok will be used modern material such as cotton, satin, I expect to be helpful to the modernization and popularization of Hanbok.

PS2-8

The Positive Impact of Image by Colour for Vulnerable People

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ABSTRACT

Image consulting has been directed to an elite society: models, executives, politicians and celebrities following the advice of an expert to develop their image.

Following fashion and brands indicates an image of success and status.

But, do only people of high social status deserve this service?

The proposal of this presentation at 2015 AIC Midterm Meeting in Tokyo is about how

Image by Colour has helped many vulnerable people.

I am currently volunteering my services in Australia to help people who are vulnerable, disadvantaged or feeling isolated from society.

For example:

Victims of discrimination,

Victims of domestic violence

Victims of bulling

People with disabilities

Insecure teenagers with eating disorders.

Women with emotional or physical hurts, whose self-worth was very low.

Refugees who need to feel validated as they start a new life.

Patients and their caregivers where disease had reduced their physical image.

International students who maybe victims of bullying by local people

In my presentation I will show the excellent results on these vulnerable sectors and how by the impact of colour has had an immediate, real and lasting effect on their lives.

The participants of "the Positive Impact of Image by Colour for Vulnerable People "project learn to re-discover their positive self-image, build their self-esteem and feel more confident to achieve their life goals - all through simply enhancing their physical appearance and the colour of their clothing.

Also, by dressing with tailored " friendly "colours and learning how to combine them, it enhances their total appearance. It enhances their skin's radiance and the gleam in their eyes.

They have benefited from this advice by feeling more confident, finding work and having hope after major life changes.

The Image by Colour service supports respect of their diversity by creating a genuine, unique and harmonious image. This influences, from the first contact, the impression others have of them.

The work was has been developed in a team, combining 30 years of my experience, with the support of the Multicultural Council of Tasmania , the Migrant Resort Centre, the City Mission , associations of disability support, people with cancer and their careers and women affected by family violence.

The first part of the project was presented in the AIC 2014, in Oaxaca, Mexico, it was well received .

I would be honoured to present the results of this continuing project in Tokyo 2015.

PS2-9

Faith in the Power of Color: Spiritual Revival from the East Japan Earthquake Disaster

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ABSTRACT

Tohoku district in Japan is a severe climate but has been blessed with the rich harvest from the sea,woods and fields. Several manner and festival for contact with Nature has been inherited there since folks recognized the existence of them. For example of "OSHIRASAMA" (would known worldwide by Ghibli film "Spiritual Away") and "float of Star Festival",color is important sign in the faith.

Those scenery of the especially coastal area was changed completely by the serious tsunami damage of East Japan Earthquake on March 11, 2011. Several tidal wave occurred by the intense earthquake had been destroying almost all while reaching a forest, and had been dredging almost all by those undertow. Though it is unbelievable on Japanese temperament,those Wreckage had been left

for a while. But those situation is conflict of preservation and departure against their life, and was also time of funeral.The landscape without every artifact as a trace of modern era has seemed a close resemblance of ancient era.

The people's mind as well as the material civilization were also injured. However, I was convinced that color has been desired from people's mind in this unprecedented lostness and has been giving the power to a recovery when I saw the brilliance of tint in the landscape of lost a focal point, for example of colorful folded paper crane or tributes flowers. There are teachers and students in uneasy mind who have been painting colored flowers on the rubble of the collapsed school building. There were those who hold carefully the color tile of the building where unforgettable person was there. There are people who revived the faith rite that succeed for several hundred years with "*Dashi*(a kind of float)" that decorated with colorful material those they could get. Flowers bloom in the fields in spring, the fruit of a persimmon looks attractive in a autumn woods, and migratory birds return to the paddy field in winter. Seeing those colors of living nature,a hope would be fired on their mind.

In this article, I would like to introduce the three cases after this disaster (traditional rite,natural view, activity of the young) to prove the power of color as well as a heal and spiritual revival.

PS2-10

Types of Smart Cities | Cities Built from the Scratch and Old Cities Transformed into Smart Cities: What Kind of Colours Can We Use?

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ABSTRACT

Cities are the habitat of the knowledge based economy. Cities produce and attract human capital and are today giant interface of communication, Cities possess the critical mass for the production and diffusion of knowledge, innovation and integration of human networks, which enable sustainable growth.

At the same time cities are the true heart of innovation.

The aim of this paper is to create architectonic interventions on this new cities for the creation of spaces that all human beings felt comfortable as they are inside old cities and with modern and sustainable fields.

This kind of new cities concept has to have more than only architecture Buildings and beautiful construction. They have to produce concepts of community for habitants and not only a networking but technologies. So this is the "bad" part inside this type of new U-biquous cities.

All the Data from this cities has to be incorporate inside an Open Community Data, where the citizens participate actively on the decisions, and an empowering citizens in the construction of a participatory e-society.

A city is not only a walkable place according to Jeff Speck: " …the author of "Walkable City: How Downtown Can Save America, One Step At A Time," a walk has to be useful, safe, comfortable, and interesting if you're going to get people out of their cars and onto the sidewalks.". A city, and the Architecture that we have inside the city has to produce feelings and sensations to the population. A city is not an object as a simple "fridge".

So, the focus is on the public spaces and on common areas inside the Buildings, how they connect with each other's is an objective and the Colours that that we use, we see and we find are points that we can´t forget.

The aim of this research is to determine some Architectural concepts that can help not only for cities, but especially for planners and architects, their role, their tools and theirs strategies.

The paper argues that the strategic plan applied on this New Smart Cities it is helpful for the future sustainability of the maintenance of the space. Architecture systems could produce outcomes on the techno-economic scenario analysis and on the socio-economic impacts

PS2-11

The Use of English Colour Terms in Big Data

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ABSTRACT

In this study, we used natural language processing methods to quantify the usage of colour names in Twitter and Google Books.

Our first task was to retrieve the most frequent English colour names from an online colour naming experiment (Mylonas & MacDonald 2010). We analysed 10,000 responses from 500 residents of UK from which 90.3% reported normal colour vision. We obtained 76 colour names responded 20 times or more. Colour name responses most often were of a single word but could consist of an unlimited number of words. In practice, there was just one qualifier such as lime green or sky blue.

To explore the usage of colour names in informal, online conversations, we collected 1,036,103 random tweets from the Twitter API. We filtered the tweets stream with the geo-location coordinates that correspond to a rectangle with edges approximately at the edges of England. We excluded tweets in other languages than English. Messages in Twitter are limited to max 140 characters and often consist of non-standard English that makes challenging the task of word-sense disambiguation. For example, it is difficult to determine whether the word 'orange' is being used as an adjective to describe the colour of an object, like an orange table, or is being used to describe a type of citrus fruit.

To investigate the use of colour names in context and disambiguate their meaning, we analyzed the frequency of occurrence of colour names in the syntactically annotated Google Ngrams Corpus of all digitized English books between 1500-2000. Looking at what other words occur with each colour name within a certain context and representing the resulting distribution in a semantic vector space allowed us to access the meaning of colour words.

The colour naming usage in Twitter and Google Books was compared with the findings from the online colour naming experiment.

PS2-12

A Proposal of a Colour Universal Design Game for Learning Dichromats' Confusion Colours

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ABSTRACT

It is well known that there is diversity in colour vision. Congenital colour-vision deficiency is one kind of color vision types. Color vision defectives cannot discriminate any colour combinations that are called confusion colours. Therefore, color vision defectives cannot receive information defined by the confusion colours in visual media or on visual displays. A color universal design has been proposed against such a dichromats' disadvantage. A basic idea of color universal design is to avoid using such dichromats' confusion colors. Some colour-universal-design aiding tools, for example Variantor (Itoh Optical Industrial Co., Ltd.) and Vischeck (http://www.vischeck.com/), have been developed recently. However, the role of these tools is to check whether confusion colours are being used by a simulation of the dichromats' colour appearance, but is not to improve the designers' knowledge of dichromats' confusion colours. The knowledge of dichromats' confusion colours would allow designers to choose colours based on the colour universal design.

The purpose of this paper was to propose a colour-universal-design aiding tool to improve the designers' knowledge of dichromats' confusion colours. We developed a game which we can learn the confusion colours in order to improve the knowledge of dichromats' confusion colours. The content and rule of the game are as follows.

1) A player selects learning confusion colours of one type of dichromats; protanope, deuteranope, and tritanope.
2) Eight pairs of confusion colours of the selected dichromat are computed. Sixteen colour patches consisting of eight pairs randomly are assigned to a four-by-four arrangement and are displayed.
3) The player chooses two colour patches that seem to be a confusion colour pair.
4) If the chosen colour patches are a confusion colour pair, the player can move to a next choice. Otherwise, the game is over.

The rule of the game is very simple. In addition, because it does not take much time to play one game, even a busy man can play the game at odd moments. We expected that the game player's knowledge of dichromats' confusion colours would be empirically improved by repetition of the game play.

We got some comments from the game players who were students of school of design, Kyushu University. Almost the comments were that it is difficult to choose the colour without any knowledge of dichromats' confusion colours although the game is interesting. Therefore, it is necessary to provide not only confusion-colour combination learning game but also basic knowledge of dichromats' confusion colours. We will examine whether the game player's knowledge of dichromats' confusion colours is empirically improved by playing the game in the future study.

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PS2-13

Colour Management: Managing the Intuitive Issue, the Gamut Issue and the Engagement Issue.

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ABSTRACT

Our work is concerned with the design of colour-picker tools and the evaluation of user-experience. Three challenges are identified; the gamut issue, the intuitive issue and the engagement issue. The gamut issue is that the display presents colours that are outside the gamut of the printer and not reproducible. The intuitive issue is that colour-selection tools are generally based on additive colour-mixing whereas users can more easily understand a tool based on subtractive colour-mixing. The engagement issue is that the focus on ease-of-use in contemporary arrangements is a problem rather than a benefit; conversely an arrangement that helps forces user engagement would help to overcome problematic assumptions that the user may have. Collectively, these issues frequently result in confusion and user dissatisfaction. Psychophysical studies have been carried out in both laboratory and design-studio settings. It was shown that users better predict the results from subtractive colour-mixing than from additive colour-mixing. It was also shown that colour-selection tools based on subtractive-mixing perform better than those based on additive-mixing. It is also concluded that users are drawn to saturated colours and if presented with these will tend to select them (without even thinking about the consequences) and that the way contemporary interfaces are designed encourages functional-fixedness doing nothing to challenge the user to think about gamuts issues, e.g., between display and print. Our research findings are used to underpin the development of a new Photoshop Plug-in ColourMimix. The software features are described and the benefits of the software are explained in terms of well-established HCI principles. The final outcome of this research is a colour-creation software that incorporates a unique interface and provides an alternative user-centred approach to managing digital colour.

PS2-14

Suggestion for Teaching Natural Colors through Investigation and Analysis of Current Color Education for Children in Korea

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ABSTRACT

Contemporary people experience colors in various forms in life and thus require professional color education. As color education has greater effects on children than adults, it is significant. According to the results of surveys and interviews targeting early childhood teachers of Nuri Curriculum (for Children, which is the common name for Korean early childhood curriculum) for 3- to 5-year-olds, Korean color education for children is difficult when instructing art activities since teachers are not professionals and materials are artificial colors. In addition, color is recognized as an important element in art activities for children, but adequate color education and activities for children seem to be insufficient. Therefore, it is necessary to enjoy the process of color training is conducted in early childhood education, arts activities within the proposed activities and a variety of colors to direct a natural conclusion to the last color you exclude the artificial colors suggest a direction to expand the parish production and art activities reaches. In this study, we propose a possible natural color scheme used in ecological education kindergarten curriculum that is the issue in Korea during early childhood to present it in depth of color teaching method through interviews with related publications.

Korean color education for children involves many activities based on the season and natural objects, but it does not emphasize natural colors. Hence, this research suggests the following: concepts of the color system, KS (Korean industrial standard) standard colors suitable for color education, activities using KS standard colors, natural color-oriented activities, use of the natural color palette for children, color management concepts, and observation of color changes of natural objects such as trees and flowers by adding chroma and brightness. Through increased understanding of the nature of color hues infant education and activities in Korea are expected to lead to continued interest in color education and research.

PS2-15

Color Mixture Learning using Personal Computer for Basic Design

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ABSTRACT

Subtractive, Additive and Juxtaposed “color mixture” are used as reproduction technique in industrial design products. In basic design education, learning of the design technique using these principles of each color mixture are significant.

Recently, we have been able to simulate a variety of color mixture results easily with PCs since spread of them. And also, students have been become able to in this way do a variety of color mixture experiences in a short time.

In this paper, we will show the design technique of the color mixtures using PC software and the students’ works and impressions after the exercises.

We introduce below training contents

1. Subtractive color mixture

1-1. Training of CMY color mixture with a colored pencil and the painting on paper (for water-color painting use). Exercises for various CMY color mixture by painting, and applying a color of the each “4-level gradation” of CMY color.

1-2. An exercise of the CMY color mixture with “the transparency film”. Layers “the transparency films” and perform CMY color mixture.

1-3. Training of the CMY color mixture simulation of the exercise of 1-1 with the PC software

Each CMY color is divided in “4-level gradation” into “every layer” and simulate subtraction

color mixture.

2. Additive color mixture

2-1. Exercise for the Additive color mixture with the lights transmitted the each RGB color cellophane.

2-2. Exercise using PC software, simulates RGB color mixture. Each RGB color assumes it "5-level gradation" WEB safe colors (hexadecimal notation).

3. Juxtaposed color mixture

As an example of the juxtaposed color mixture, to design the color pattern of the cloth of the plain weave by PC software. Based on an example of the gingham check pattern using CMY, create designs with student's original color.

We will introduce below the impression of the students after the training.

"A function called color multiplication was convenient and understood well that it was interesting."

"When it was easy to make a translucent design and the design with the united feeling, I felt it."

"I had color constitution like today (in this training), and even other classes only changed a position to be piled up a little and an impression changed completely and was interesting".

"I was able to imagine only that I mixed paint when I heard the word color mixture, but I came to be able to imagine the color mixture to repeat by having used "transparence origami" and the layer by this class"

Understanding from these impressions, significance of the training is suggested.

PS2-16

The Art of Colour Harmony: the Enigmatic Concept of Complementary Colours

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ABSTRACT

This paper explores the theory and practice of colour harmony based on the equilibrium of complementary colours. For centuries artists relied for their colour choices on studio experience and artistic knowledge handed down from master to apprentice while "scientific" colour theory remained mostly the preoccupation of scholars and philosophers. Many of the latter kind of theory were based on a comparison of visual harmony with musical of harmony (Kemp 1990; Gage 1993, 1999). This paper presents some reflections on those theories and argues that they have lead the research of the aesthetics of colour astray for centuries.

Complementariness in colours is sometimes described as oppositeness, although strictly speaking complementariness and oppositeness are different concepts. It is unclear, when theories of the oppositeness of colours entered the language of art, but the term complementary colour is less than two hundred years old and comes from the physics of light. A "complement" is something that completes or fills in a missing portion of something. In the case of light the missing portion is a certain part of the spectrum of light that added to the rest of the spectrum completes it to produce "white" or neutral light. This phenomenon was described by Newton in his work Opticks (1704). A century later Johann Wolfgang von Goethe presented a rival theory, this time of complementary sensations rather than complementary stimuli (Zur Farbenlehre, 1810). This theory shifts the phenomenon of complementarity or oppositeness from the realm of physics to the realm of phenomenology, from the stimulus to the sensation. Most modern theories of the oppositeness of colours, their position in the colour wheel and their role in theories of colour harmony can be traced to these two sources.

Other theories of complementariness and harmony simply make reference to a colour wheel, stating that colours found diametrically opposite on the wheel are complementary to each other. Some textbooks insist that these relationships are extremely precise, because of their scientific foundation (Itten 1963). Others, while promulgating a colour wheel -based harmony theory, admit that this principle is made rather uncertain by the fact that the colour relationship depends entirely on how the wheel is constructed.

In his article *Är komplementärfärger mer olika än andra färgpar*? (Are complementary colours more dissimilar than other colour pairs?) Professor Anders Hård showed how ambiguous the concept

of complementarity is even within a scientific frame of reference. He also concludes that artists "grasped the new scientific theories of subtractive complementaries, complementary stimuli and simultaneous and successive contrasts, as acceptable explanations, proof or definitions of phenomena that they had since long ago known and worked with." (Hård 1985). The "harmony" or "disharmony" of colours, whether based on complementariness or other relationships, is not scientifically quantifiable, but a qualitative aspect that requires artistic knowledge, sensibility and attention to several simultaneous layers of experience.

PS2-17

A Study on Influence of the Culture and Art Experience of Senior Citizens from Relationships between Culture and Art Education Space and Color Emotion Assessment

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ABSTRACT

The ratio of the aged population in the total population of the Korean society is expected to continue to increase and it will increase by 14.3% in 2018. From now on, the expected future lifetime of the aged will be much longer and the life of the aged period will continue on one's own planning like the life during one's young and middle-aged time for over 20 years after one's retirement unlike that in the previous times. Accordingly, the government is shifting welfare policy for the aged to a new direction in terms of the country and welfare policy for senior citizens expanded common services, which had been provided only for the aged on living protection and in low income, to general senior citizens.

In fact, most of senior citizens are experiencing culture and art such as the government's common services in Korea due to the increased living conditions and quality of life. In addition, culture and art education facilities for the aged increased by 41 facilities to 300 facilities from 259 facilities for 3 years from 2010 to 2013, while spaces for the aged are rapidly built up for their use and purpose as well. Accordingly, it is necessary to carry out studies to provide the improved facilities and environments in a way for the aged to feel their physical and psychological stability in accordance with cognition on the aged together with the given purpose of spaces, along with our aging society. However, studies relating to cognition on the aged and environments on culture and art spaces are lacking when we analyze the study trends which have been carried out up to the recent time.

This study analyzed the influence of the culture and art experience of senior citizens on their color emotion assessment from relationships between culture and art education spaces and color emotion assessment through the analyzed data after the status on space colors in culture and art education and color analysis per space component in Korea were identified. The multiple regression analysis, moderated regression analysis and T analysis were carried out using the SPSS statistic program 21 to achieve the purpose of this study.

As a result of the study, the color, brightness and chroma of education spaces were concentrated on those colors such as orange (O), yellow (Y) and yellow green (YG). The most influences appeared when the colors of walls expressed spaces among 3 elements such as the ceiling, wall and floor. The findings of this study are expected to be used for important data in the color planning for indoor education spaces for the culture and art eduction spaces of the aged.

PS2-18

Impressions of Buildings Derived from the Combined Effects of Exterior Colour, Material, and Window Shape

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ABSTRACT

External appearance is an important factor in determining impressions of buildings, and is greatly affected by the building's architectural surfaces. In this study, color, material, and window shape were focused on as elements that affect the visual impression of a building's appearance. The strength of the impact that these elements have on impression, and the mutual relationship between them, has not been made clear in studies to date.

Thus, the purpose of this study is to understand the extent to which these elements impact impressions of a building's appearance.

A series of experiments was conducted to determine impressions derived from surface designs using the semantic differential method. As noted above, the parameters were exterior color, material, and window shape; the structure used was an office building. In all, 29 colors were selected from the Munsell Color System, and three types of materials were selected from general exterior materials used in newer Japanese office buildings. Two types of window shapes were selected from general exterior designs of office buildings. In order to display these elements to the study participants, 174 perspectives of buildings were created as stimuli, using computer graphics. The stimuli were presented to participants on a 21-inch CRT display at random.

Evaluations were sought from 38 observers using 30 semantic differential seven-point rating scales.

Image profiles were drawn using the average of each stimulus from the results of the experiments. The results show that the most influential factor was color. Regardless of the material and window shape used, high evaluations were elicited when the graphics were composed of colors with high Value and low Chroma.

Three factors—"evaluation," "potency," and "warmth"—were extracted from the results of the factor analysis. These factors can be characterized by the parameters. According to the factor scores, the impact from impressions of color, material, and window shape was not a constant trend. An impression evaluation was determined by the effect of the combination of these elements.

The results of this study show that color is the most affective element with respect to impressions regarding architectural appearance; however, material and window shape also have an impact. Therefore, it is important to ensure that designs are created through a combination of these three factors.

PS2-19

Analysis of Current Colors of Native Plants Growing Naturally in Korea

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ABSTRACT

Although there are numerous magazines and specialty publications covering a range of plants from foliage plants to wild flowers, plant colors are often misunderstood. Although color atlases for the design field have been developed, they are limited in their applicability to plants. The RHS color chart published by the Royal Horticulture Society is used as the standard for classifying flower colors by adjusting chroma and brightness based on principle hue. Although the RHS color chart is used in Korea for classification of plant colors, its specificity for British flowers limits its applicability to Korean wild plants. As it is not generalized in the ordinary domain other than plant majors, it is hard to share information in other fields except for the relevant field. In addition, there are limits in terms of peripheral temperature, humidity, light conditions, and subjective perception of color.

This research tried to develop an objective and rational standard color atlas for native plants growing naturally in korea.

From February 2013 to January 2014, wild plants were photographed using Colorchecker Passport (Standard Colorchip), and colors were extracted using the Lightroom program. In analyzing native plants by season, a total of 187 color values were extracted, and Yellow Green showed the highest extraction with 37.9% of 116 colors extracted in the spring, followed by Yellow with 29.3% extracted in the spring. Of the 63 colors extracted in the summer, Yellow Green showed the highest extraction at 36.5%, and Yellow showed 31.7%. Orange and Reddish Purple were 9.5%, respectively.

Of the eight colors extracted in the fall, Yellow Green and Yellow showed extractions at 37.5%, and Purple and Reddish Purple at 12.5%, respectively. In the winter, native plants hibernated and were not extracted. Based on this research, the availability of natural colors will increase. Studies on color atlases on plants in Korea should be conducted.

PS2-20

Effects of Accent Colour on the Apparent Distance to a Wall and the Apparent Volume of an Interior Space: The Validation Experiment in an Actual Space

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ABSTRACT

1. Introduction

Colour produces many psychological effects, such as contrast, assimilation, advancing, receding, and area effects, among others. This study considered the advancing and receding effects of colours on the apparent distance to a wall painted in a single colour within an interior space using scale models. However, houses contain many accessories, such as curtains, blinds, paintings, and so on. These are perceived as accent colours in an interior space. Thus, the study also sought to evaluate the effects of accent colours on a wall, with consideration given to the apparent distance to the wall and the apparent volume of the interior space using scale models. However, these effects need to be confirmed in the actual space.

2. Experimental method

Psychological experiments were conducted in an actual experimental space. A thin, square panel painted in a single colour was hung in the centre of the wall.

There were three experimental conditions based on the panel size: a large panel (hereafter referred to as EC50) occupied 50 per cent of the wall; a mid-sized panel (hereafter referred to as EC10) occupied 10 per cent of the wall; and a small panel (hereafter referred to as EC2) occupied 2 per cent of the wall.

Seven panel colours were selected, and 14 subjects asked to evaluate the panels' apparent distance to the wall using a seven-point rating scale. They were also asked to evaluate the apparent volume of the room using the magnitude estimation method.

3. Results

3.1 Apparent distance to the frontal wall

For EC50, the wall seemed to advance for all colours except white. The degree of advancement was greater for warm colours, as well as for black and purple.

For EC10, the wall seemed to advance for all colours. The degree of advancement was greater for warm colours.

For EC2, the wall seemed to advance for all colours except blue and green. The degree of advancement was greater for warm colours.

3.2 Apparent volume of the interior space

For EC50, the interior space appeared small for all colours except white. The degree of shrinkage was greater for warm colours, as well as for black and purple.

The values of EC10 showed a similar tendency to those of EC50. However, the degree of shrinkage for EC10 was smaller than that of EC50.

For EC2, the interior space appeared small in relation to warm colours, while it appeared larger when blue and black were used.

4. Conclusions

The following conclusions were obtained by conducting experiments in the actual space.

In terms of the presence of an accent colour on the wall, the apparent distance to the wall and the apparent volume of the space can vary.

The apparent distance to the wall and the apparent volume of the space depend on the area of the accent colour, as well as its hue.

PS2-21

Metamer Mismatching as a Measure of the Color Rendering of Lights

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ABSTRACT

We propose a new method for evaluating the colour rendering properties of lights. The proposed method uses the degree of metamer mismatching for flat grey (constant reflectance of 0.5) quantified in terms of the metamer mismatch volume index proposed by Logvinenko et al. [2]. The standard CIE color rendering index (CRI) [1] has been widely criticized, especially when evaluating LEDs. One of the key problems with it is that it is based on measuring the colour differences that arise across a small sample of 8 (sometimes 14) coloured papers. Not only may such a sample not represent what the colour differences for all other possible surface reflectances may be, it also gives manufacturers the opportunity to tune the spectra of their lights to perform well on the standard sample. The background for the proposed measure of colour rendering is the concept of metamer mismatching. Consider a colour signal XYZ (in CIE standard coordinates) observed under a first light. Metamer mismatching refers to the fact that the possible XYZ that might be observed under a second light are only constrained to lie within a convex volume of possible XYZ values. The size of the volume depends on the XYZ and the lights involved; however, the volume for flat grey is the largest. The metamer mismatch volume represents the range of possible XYZ that can arise under the second light and so provides a measure of how different the XYZ under the second light can be. As such, it provides a measure of the colour rendering properties of the second light relative to the first. Since the metamer mismatch volume scales with the intensity of the illuminant, it is helpful to normalize the mismatch volume by the volume of the object colour solid for that illuminant, since it scales correspondingly with intensity. The result is the metamer mismatch volume index (MMVI) [2]. In terms of colour rendering, the larger the MMVI, the poorer the colour rendering is likely to be. Since the MMVI is volume based, it is more intuitive to consider MMVI^(1/3). The Metamer Mismatching Colour Rendering Index (MMCRI) is then defined as MMCRI = 1 – MMVI^(1/3), where the MMVI is that of flat grey. We have computed the MMCRI and CIE CRI for numerous light spectra and compared them. In particular, we measured the spectra of several commercially available LED lights of various correlated colour temperatures and also used the spectra of CIE standard illuminants. When plotted (unavailable in this text-only abstract), we see a good correlation between the two indices--- an indication that the MMCRI behaves reasonably--- but with notable differences for some illuminants. It is exactly such differences that the proposed new method is intended to reveal. A complete analysis is presented in the full paper.

References
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PS2-22

Visual Impression of a Real Room Affected by Lighting Conditions and by Colour and Texture of the Walls

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ABSTRACT

Colour scheme plays an important role in the process of interior design. Different combinations of wall colours, textures and lighting conditions can bring out differences in terms of semantic feelings and aesthetic judgements. That makes an important issue to find out appropriate combinations of colours and light sources for an interior environment. To address the issues, interior colour design was taken as an example in our psychophysical study of wall colour and lighting conditions.

The aim of this study is to investigate visual impression of a real-room space, a “shooting studio” with a size of 3m (width) x 3m (depth) x 2.5m (height). The backgrounds for the three “walls” were made of coloured cloth sets that can be changed easily by a rail system. The lighting conditions

were varied by adopting different light sources. Six wall colours were used in the study: grey, white, black, light brown, light blue and light green. Six lighting conditions were adopted, generated by two correlated colour temperatures (CCT), 6500K and 2700K, and three lighting directions, including (a) light travelling up and sideway, (b) a non-directional floor lamp and (c) light travelling down). This resulted in 6 (background colours) x 6 (lighting conditions) = 36 experimental conditions. In addition to these 36 experimental conditions based on cloth background, 12 extra experimental conditions based on paper background were also used to investigate whether the results were influenced by the background texture (i.e. cloth vs. paper). The 12 paper-background experimental conditions were selected randomly from the 36 cloth-background experimental conditions in terms of wall colours and light sources.

Ten semantic scales, including like/dislike, comfortable/uncomfortable, warm/cool, spacious/small, bright/dark, clean/dirty, relaxing/tense, elegant/inelegant, classical/modern and harmonious/disharmonious, were used to measure the emotional effects of combinations of the wall colours and the lighting conditions. Twenty-two observers with normal colour vision, including 11 males and 11 females, participated in the study. During the experiment, each observer was asked to sit in the room and to rate for each experimental condition using the 10 semantic scales.

As a result, the 10 scales were classified using principal component analysis into two underlying factors, "brightness" and "warmth". The "brightness" factor was found to correlate closely with bright/dark, clean/dirty and spacious/small. The "warmth" factor was highly correlated with the remaining scales. Note that "like/dislike" was correlated more closely with the "warmth" factor (R=0.75) than with the "brightness" factor (R=0.45), implying that warmth was more important than brightness to increase the preference. High correlation was found between the cloth-background and the paper-background experimental conditions in terms of all semantic scales, with the highest correlation coefficient 0.92 for classical/modern, followed by 0.90 for spacious/small, and the lowest correlation being 0.66 for both like/dislike and comfortable/uncomfortable. This suggests that the texture of walls had a stronger impact on preference and comfort than on the other scales.

PS2-23

Suggesting Appropriate Color Range for Indoor Space Based on EEG Measurement

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ABSTRACT

Color influences the human body in physiological and psychological manner, and interest in research on revealing such influence through brain wave measurement is increasing. The current study observed human physiological reaction in different indoors color environment, through an analysis of brain wave in the range of 8 to 13Hz, commonly known as the alpha wave. The frequency of RSA (8-11Hz/4-50Hz), or "slow" alpha wave, and RFA (11-13Hz/4-50Hz), or "fast" alpha wave, were studied. Centering on the changes to the brain wave after the color stimulus, the current study analyzed what influence 9 different colors had on the human body. Four groups came out in the result: 1) Red, Green-Yellow, Blue-Green, Yellow-Red incurred decreased RSA and increased RFA; 2) Yellow increased RSA and decreased RFA; 3) Blue and Purple increased both RSA and RFA. 4) Green and White decreased both RSA and RFA. The results of the current study is useful in that they can be used as a practical data for classifying colors appropriate for various purposes in residential spaces. In residential spaces, these colors are more appropriate for living rooms, in which rest combined with basic activities takes place, rather than bedrooms, in which rest leading to sleep takes place.

PS2-24

Development of the Interior Color Coordination Recommendation System of Living Space for University Student Living Alone Using Genetic Algorithm

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ABSTRACT

How to coordinate interior color of the living space is important issue for the living person from the quality of daily life point of view. Especially for a person living alone, whether he/she can get the private space or not for relax atmosphere or private environment for working and so on is highly depend on the interior color coordination of the space. From this background, in this study the Interior Color Coordination Recommendation System of Living Space for University Student Living Alone have been developed by mainly using Genetic Algorithm (GA). Firstly, impressions for interior color coordination of the living space where average university student lives alone were investigated. Total 102 (54 males and 48 females, average=21.45, SD=1.25) university students who lives alone were required to evaluate their impression for over 30 CG images of color coordinated living space by 30 adjectives using selection of YES/NO as adequate impression. Next, the relationships between colors and adjectives that represent impressions of living spaces were detected by Factor Analysis and to detect 13 factors as Pop, Cool, Elegant, Natural, Formal, Eccentric, Light, Classical, Tropical, Dandy, Profound, Quiet and European. According to the above results, some features of CG images of color coordinated living space were depicted using the factor scores for each 13 factors and 3 evaluation functions for GA operations were defined using the relationships between colors and adjectives that represent impressions of living spaces Through some evaluation experiments of the system, following results were found out. (1) In case of setting equivalent weights for each evaluation functions, the matching degree between system output and user's image indicates the highest value, (2) The more reflected users' image on selecting the adjectives for living space, the higher possibility of appropriate system output for users' ideal living space and (3) How to reflect users' preference for color is one of the most important factor for the system performance.

PS2-25

Chromatic Integration of the Architectural Surfaces with Environment: Analysis and Classification of Case Studies

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ABSTRACT

The introduction and application of new products in the building market, joined to the continuous elaboration and re-interpretation of already known materials, in particular of those dedicated to the facades, produces new effects on the perception of the chromatic truth of the places where these are employed. Among these products and materials there are someone, employed in multiple shapes, finishes and textures, those use has been consolidated in the realization of facade claddings (concrete, metals, glass, plastics, composites, smart etc.). Their use in the context in which these facades are located produces particular chromatic effects, different from those of the tradition, or similar to it: chromatic agreements, contrasts (see J. Itten), dematerialization of the building envelope etc. Is it possible to lead a chromatic analysis of meaningful cases having the target to supply useful instruments to the design phase?

This study has the proposal to complete a chromatic surveying of famous buildings by the means of common graphical instruments such as the pixel filter: a tool useful to identify the dominant

tones that can be obtained from a photographic relief. Captured colors can be inserted in a diagram to classify their combinations: one dominant, two colors, three colors, four colors, contrast of light and dark, contrast of warm and cool colors, etc..These kind of studies would have to lead us to the definition of a table of chromatic harmonies and contrasts. The study means to consider all the elements of the context: sky, green, water, buildings etc, so as to be able to contemplate also the chromatic variants due to the change of the luminous or atmospheric conditions. Knowing that "varying the field of vision whichever chromatic manifestation can be obtained, just because seeing it is not never an objective fact, but it is participation, subjective interpretation" (J. Tornquist, 1999).

PS2-26

Color Appearance of Red Printing Ink for Color Vision Deficiency

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ABSTRACT

In package printing industry, spot color ink generated by mixing base inks has been used more often than CMYK process ink. In particular, red color ink is required not only for designability but also for using to refer notes on many packages. Therefore, it is important to investigate conspicuous red color inks for various illuminant conditions and color vision deficiency. Further, we are able to create spot color ink to reproduce metameric colors that appear the same color shade with different spectral distribution by selecting the base ink combinations. It would be possible to provide a new recipe for red color ink with improved visibility.

We made red spot color inks which consisted of several base inks, and printed on coated papers using those spot color inks. Then we prepared 37 printing samples covering 10RP to 10R in Munsell hue with the middle range of value and relatively high chromas. The size of samples was 7.5 by 4.5 cm. Observers with normal color vision and color vision deficiency evaluated the redness of the printing samples and their discriminability from a black background under two illuminance levels, 500 lx and 1 lx. The type of illuminant was a D50 fluorescent lamp. For the evaluation of redness, the observers viewed each printing sample on white backgound and scored using five scale. For the evaluation of discriminability from black, the observers viewed each sample on black backgound and scored in the same way as redness. The evaluations were made three times for each sample in each condition.

The results of evaluation for redness show that the samples whose hue are from 2.5R to 7.5R and high chroma obtain the high score of redness for at 500 lx in general. At 1 lx, samples with yellowish red hue and high chroma obtain the high score of redness for observers with color vision deficiency, especially for protan. The results of discriminability from black is more correlated with the lightness of samples at 1 lx than at 500 lx. The samples with high chroma are highly discriminabile for both normal and deutan observers. The scores of protan observers for yellowish red hue and high chroma are high at 1 lx as same as the results of redness. Better discriminability for those samples would be due to the higher middle-wavelength (yellowish color) components in the spectral reflectance of those samples.

Our results suggest that we are able to predict an appropriate red spot color ink for various illuminant, color vision deficiency, and application usage.

PS2-27

A Study on the Utilization of Korean Saekdong Color in the Textile Arts

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ABSTRACT

Saekdong is a typical color arrangement that symbolizes today's Korea. The unique color composition and plastic characteristics are products of representative aesthetic awareness wherein the cultural senses inherent to Korean people are condensed and have been closely used during the daily life of Korean people from the Era of the Three States to the modern times. For the arrangement, structure, and ratio of Saekdong, they are typical stripe patterns symbolizing the philosophy and outlook on the universe of Korean people rather than a simple sense of beauty; such can be called Korea's traditional color senses and the harmony of color arrangement featuring moderated modern beauty.

The background of thought formed based on such sense of color of Korean people is the color sensitivity of the Obang colors (five directional colors) created on the basis of the color sensitivity of Obang colors based on the Eumyang-Ohaeng theories introduced through China. According to such thought, however, Korean people expressed strong aesthetic consciousness of the intention of good omen through Saekdong, the peculiar color sensitivity made by patching cloth of various colors and maintaining it as the traditional color pattern unique to Korean people. The colors most used for Saekdong were the 4 colors of Obang colors excluding black, wherein a mix of various colors were combined with blue, red, yellow, and white to ensure soft color transfers.

During the initial stage, Saekdong existed in common in the three states, e.g., Korea, China, and Japan. Note, however, that the Saekdong color arrangement took root in diverse ways only in Korea, becoming typical products of beauty wherein cultural senses inherent to Korean people were condensed. In particular, the unique sense of rhythm created from the repetitive arrangement of a specified unit amid the asymmetrical natural sense of balance of the left and right of the original colors and the mixed colors is the excellent plastic art element of Korean Saekdong.

Nevertheless, the range of using Saekdong has gradually decreased - much to our regret - with the advent of modern times. It is used in domestic markets as part of tourist products and only on the sleeves of the improved Hanbok (Korea's traditional costume), from which it is difficult to find the identity of Korean people. At the same time, the application of modern design to the component colors of Saekdong is extremely passive owing to the strong traditional image and ornamental effects. There is also a considerable lack of studies on the expanded spectrum of the modern Saekdong colors aimed at expressing the Korean-style image. To date, there have been many cases of developing design that has simply borrowed only the format of stripe patterns in foreign countries. Realizing that not all of the many stripe patterns remind one of colors unique to Korea, however, one should use Saekdong more actively in one's daily living based on the differentiated peculiar color sensitivity contained in Saekdong.

Therefore, this study was carried out based on the report on studying contemporary plastic art works of diverse genres to revitalize Saekdong, which shares Korea's identity as well as the aesthetic consciousness of world generality. In particular, the writer has completed modern plastic art expression by reflecting the color sensitivity of Saekdong on various experimental plastic art works such as <The Cord of Life> done by the writer in the past. The morphological elements of works are as follows:

First, as the relief plastic element of patch work, the work expresses relief form through the plastic art combination and coloring of diversified materials - not the existing needlework technique - based on the plastic section division and patching technique of Korea's wrapping cloth. The writer sought diverse colors of the Saekdong colors reinterpreted on the delicate textile materials and the contemporary plastic expressions in the geometric configuration resulting from the material patching.

Second, as a pictorial Saekdong object element, the Saekdong object was assigned as the first accent color of the color planning of the works to express the coexistent energy of life, attempting to reflect the sensitivity of the Saekdong colors on the plastic work as much as possible by extracting strong metaphorical color language from the Saekdong pattern and to compose a screen with the principal and auxiliary colors and No. 2 and No. 3 accent colors. In particular, geometric stitches of modern expression symbolizing the pattern of good omen - which frequently appeared in traditional Saekdong - were inserted in the Saekdong cloth appearing as object.

Third, the existing shape of the large plastic works of Obang colors worked for a long period of time as a linear element combining the Saekdong colors with motif as depicted in the form of line, the symbolic expression element forming the motif. The Saekdong colors were introduced to the monotone motif containing much energy and were substituted into the thin frame of the cube left empty except the corners by expanding the open space of the Saekdong cube to include time and space. This is the aesthetics of □Space□, which has only line left, and the principle of life; here, it means that

□Space□is the philosophy of non-owning and refers to the space of the blank that can be filled with new ones by emptying it.

Fourth, as the cubic fusion element of the screen configuration, geometric cubic configuration was carried out on each screen of the plastic works by showing the coexisting figures of nature and man on earth and through the color drawing of continuous circulation and recycling; the colors of the disassembled Saekdong colors and the motif pattern of the black and white □Cord of Life□ were combined on the screen. In addition, not only was the front side of the screen used for configuration; the screen was also configured in various aspects.

Fifth, as the image and the light work element of the Saekdong motif, the Saekdong motifs installed in space were used to demonstrate another light along with the image wherein each of the Saekdong motifs installed in space became living and moving things. The moving lights in the Saekdong motif were combined, and the Saekdong colors in the installed motif emerged; this in turn made the Saekdong colors appear as though they were alive. The contemporary plastic works carried out through such diverse experiments sought to prevent Korea's Saekdong colors from being rendered unable to escape the limitations of the unchanged image such that only variations are repeated and to use them actively. The following is a summary of the analysis conducted on the construction of plastic works through various experiments:

First, among the Saekdong types shown in the traditional costumes, a cubic screen expressing images of the typical formal dress and holiday dress in a modern way was configured, and the pictorial work was carried out in relation to the modern plastic interpretation of the Saekdong color arrangement. In particular, the configuration of the geometric aspect from the sleeves of Korean Ceremonial Robe was introduced to the special cubic canvas, and the background screen launched a nature-assimilating thinking background based on the traces of drawing and the "Tone on tone" arrangement of colors.

Second, the color sensitivity of Korean people as contained in Saekdong through the installation work based on the reinterpretation of the Saekdong colors was expressed in a large ideal earth connecting the past with the present. The residual Saekdong cloth pieces after using the cloth for the plastic work so far were scattered on the floor to create diversified color groups, attempting to express the great earth of behavioral residues covering both the past and the present.

Third, the work expressed a scene wherein the cube of the black and white motif was transformed into a Saekdong cube through the 3D space installation work of the Saekdong cube to express a figure wherein the cube is floating in space, with each corner attempting a modern variation of the Saekdong colors.

Fourth, motives were launched in diverse patterns; the results of studies on more expanded extensity amid an organic sense of expansion were presented through the digital cubic work wherein the Saekdong cubic blocks that had prepared for the vitality of the strong Yang of <Blue and Red) were left floating in the enormous space orbits.

One important precautionary point that should not be overlooked in relation to diversified plastic works under this study is that it has attempted at the modern plastic expression of the Saekdong colors with the premise that the image of the results should carry unique global competitiveness having specific nationality. To date, there have been many plastic works and prior studies and analysis carried out on colors regarding plastic works and Korean-style image expression. Through the diverse and aggressive plastic experiments carried out on colors unique to Korean people, gone will be the times when such colors might be ignored owing to traditionality.

They also provide an opportunity to use such colors positively as the global color sensitivity contents based on the plastic superiority of the Saekdong colors of Korea. We hope that various color tests and experiments are carried out continuously in the future to modernize the Saekdong patterns.

PS2-28

Color Adjustment for an Appealing Facial Photography

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ABSTRACT

Called as 'Selfie' in the social network services(SNS), a self portrait photography is one of the

popular behaviors of SNS users. Due to a growing concern about more attractive and professional Selfies, most of the SNS are offering image filters. This study investigates how the image filters affects the judgment of portrait images. In particular, we aim at finding an underlying relationship between the color change that is occurred during the imaging filter process and the affective judgment of portrait photography.

For the investigation, we collected ten Asian portrait photography made up of five males and five females, and all initial look was judged as being neutral. For the subjective judgment, we used four facial emotions: intelligent, humane, energetic and solitary. Consequently, we generated 40 stimulus sets by multiplying ten photography with four facial emotions. For the investigation, the photography was presented in 2.4(width) by 4.2(height) in inch that simulates a 4.8 inch smartphone display and an emotion term was shown below the photography. A total of 40 college students participated in the test and they were comprised of 20 males and 20 females.

To enable the color modification of the given photography to properly express the given facial emotion, we developed a HSV control unit. The unit consists of three dials and each dial varies the hue, saturation, and value properties of an image independently. One turn of hue dial shifts the hue angle by 0.1 degree(0~360) whereas one turn of both saturation and value dials shift 1 percent(0~100). Each participant was asked to manipulate the H, S and V dials until they reached to the satisfactory level. When the color modification is completed, the modified portrait was uploaded to the server and the next stimulus set was presented. Each participant went through randomly selected 10 stimulus sets.

The major findings are unfolded into three: (1) Depending on the emotion term, color modification was differently applied. For example, to appeal intelligent look, saturation was decreased, while hue and value were maintained. In order to appeal humane look, hue was turned toward warm range between red and yellow, and value was increased. In such a way we found certain combinations of manipulations of hue, saturation, and value to highlight certain emotional look. Also most of the interaction effects caused by the three attributes were statistically significant at an alpha level of 0.05; (2) Overall there is a tendency that female photography was more apt to become brighter and more reddish across the entire four emotion terms, especially when male participants manipulated female photography. (3) The perceptual color difference of human face is non-linear among the three color attributes. Participants were the most sensitive to the change of hue followed by value and saturation.

In addition to the empirical findings we discussed how to expand this study by incorporating with other modifications such as contrast and sharpness to achieve a more practical and versatile Selfie service.

PS2-29

Understanding Popular Relationships among Colors through the Network Analysis for Crowd Sourced Color Data

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ABSTRACT

Color is a compelling cue that affects the aesthetics and the mood of an art work or a design. In order to support proper color choice, there have been attempts to develop algorithms or tools that generate a set of colors which looks aesthetically appealing. However, constructing a satisfied color scheme is still challenging due to the limited practicality and weak theoretical background of existing models.

In this regard, this research aims to investigate patterns of color combinations through exploring the latent relationships among colors in color schemes. A network analysis was adopted to examine the relationship of colors and to identify key players of the color network.

For the network analysis, we collected 44,986 color themes from Adobe Kuler(Adobe Color CC) database and filtered out 7,118 popular color themes whose scores are higher than 4.0 out of 5.0. Then we transformed each color theme into nodes and links data. A node indicates a single color, and a link is a connection between a pair of color. Since every color scheme consists of five colors, we extracted five nodes and ten connections (10= (5 x 4)/2) from each color scheme. In addition, the RGB scores as it was initially crawled were mapped into the CIE1976L*a*b space. The L, a, b scores were rounded off to every 5(for example a color with L:71, a:14, b:13 was transformed to L:70, a:15, b:15).

Consequently the color quantization aggregated multiple colors into one, and helped to construct a concise and denser network.

As a result, a network with 4,922 nodes and 26,401 edges was generated, and measurements of centralization and modularity were calculated. The centrality suggested that colors with extreme L value were used more often to construct a color scheme than colors with moderate L values. In particular, colors with higher L values showed remarkable centralities throughout the entire color network. In the aspect of Chroma, most of reddish colors appeared in the low range of L, whereas bluish colors more frequently had higher L values. In overall, however, highly centralized colors had relatively low chromaticity. The analysis of modularity revealed that colors showed a strong tendency to be grouped with colors which had similar hue. These results shows a relationship between hue and the distribution of L values within a color scheme. As we attempted, the network analysis can provide implications how popular colors are related in a quantitative and intuitive way and enables comparative analysis in various viewpoints quickly and easily.

PS2-30

Eliciting the Color Bizarreness Effect Using Photographs

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ABSTRACT

Color typicality has seemed to affect on performance of a picture memory task. When an object is typically colored, the color is remembered more accurately than when it is atypically colored. It is explained by the fact that we can access the prototype easily when the object is naturally colored. This color typicality effect seems to be robust. In contrast, incongruent stimuli (sentences, images, pictures) have been found to increase attention, resulting in higher performance on memory tasks compared with congruent stimuli, the so-called "bizarreness effect". The previous study by these authors investigated the color bizarreness effect in line drawings.

The current study investigated the mechanism producing the color bizarreness effect. We manipulated the object color of photographs, rather than that of line drawings. We expected that the strangeness of the bizarrely colored stimuli is larger in photographs than that in line drawings. The objects pictured were exactly the same as those in the previous study, which found a color bizarreness effect with line drawings.

The participants in this study comprised 30 university students. In an initial learning session, 28 photographs of objects were presented one at a time. They were colored in typical colors (e.g., yellow banana, purple eggplant) or bizarre colors (e.g., blue banana, orange eggplant). The participants were asked to evaluate their impressions of the photograph. After the learning session, participants were assigned to a 2-minute interference task. This was followed by a 3-minute free-recall test session.

The recall performance results did not show a bizarreness effect or a typicality effect. Why the bizarrely colored photographs did not produce color bizarreness effect is discussed. Previously, the authors examined the color bizarreness effect using line-drawings. The procedure was exactly the same as this current experiment except that the stimuli were line-drawings, not photographs. That experiment did produce bizarreness effect. An ad-hoc analysis found that the strangeness of the filler stimuli, that is, typically-colored stimuli, affected the bizarreness effect; because the typically-colored photo stimuli seemed to be a little unnatural, bizarreness effect decreases.

This mechanism for the color bizarreness effect can be applied to create striking text or advertisements.

PS2-31

Texture in Color Emotions

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ABSTRACT

Color directly affects the part of human nervous system which is responsible for emotional arousal. In this context emotions are regarded as complex processes of connected events which include stimulus, cognition, subjective feeling, behavior and effect of that behavior. In order to experience an emotion, a person needs a stimulus of certain kind; it can be inner (i.e. thoughts) or outer (i.e. event or encounter). Interpretation of stimuli then serves as a base for the feelings which are likely to follow.

Speaking about visual sensation much effort is put into investigating color emotions, and into building the models by selecting emotion scales and assessing human reaction to selected colors through these scales. The colour emotion studies aim to create a model able to describe and quantify emotions, and eventually predict the degree of preference for certain colour based on its psychophysical attributes. Some of the parameters that can influence color perception are the nature of the object, immediate surroundings, etc. but also the effect of the language, culture and previous experiences and knowledge of the observer. All of these parameters must be taken into account. Most of previous studies have recorded color emotions in subjects viewing uniform color samples. However, when dealing with the real world objects, perception of the color is usually connected with the perception of objects surface properties i.e. texture. Texture as a surface property plays a crucial role in object identification and recognition. It is also proven that the same color can be perceived differently, and consequently evoke different emotions, if it is combined with different textures. Hence, in order to develop more applied model for evaluating object color preference and emotions, texture must be taken into account.

The aim of this study is to describe how particular textures, in combination with colors, affect human emotions and preferences. If it is possible to find a relation between certain textured sample and human response to it, information obtained can be used in so many industry applications such as product automobile, textile, medical image, design and display, as well as in advertising of any kind.

PS2-32

Individual's Color Preference and Personality of Feeling Active and Passive Good Emotion, Pleasantness and Comfortableness

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ABSTRACT

We investigated relationship between individual's color preference and his/her personality of feeling pleasantness. Pleasantness is human's emotion of good feeling, which is characterized by activeness, change, and surprise. It is often contrasted with comfortableness, which is characterized by passiveness, stability, and ordinariness. A hundred university students, forty-five males and fifty-five females, were asked to answer the questionnaire. The questionnaire was composed of two parts. The first part included twelve visual analog scales on which participants answered degree of liking of twelve basic colors; red, orange, yellow, yellow-green, green, blue, purple, pink, brown, white, black, and gray. These colors were presented as printed color chips. Participants drew a slash, according to the degree of liking of each color, on the line with the left-end indicating 'don't like at all (0% liking)' and the right-end indicating 'like the most (100% liking).' The second part showed participants six short sentences, each of which depicted good affair. Three of them depicted pleasant situation (P sentence); e.g., 'win a prize of 5,000 yen.' Another three depicted comfort situation (C sentence); e.g., 'stay relaxed in a moderately air-conditioned room.' For each sentence, participants were asked to imagine how strong he/she will feel emotions presented as ten emotional words and answer the degree on 11-point scale. After an exploratory analysis of obtained data, we selected two emotional words ('glad' and 'excited') as indicators of pleasantness, and two words ('relieved' and 'relaxed') as indicators of comfortableness. Then we conducted correlation analysis between individual's color preference and his/her tendency of feeling pleasantness and comfortableness. The results showed that the individual who is sensitive to pleasantness on P sentences tends to like black and purple, and the individual who is sensitive to comfortableness on C sentences tends to like orange, green, and yellow-green. It is suggested that these colors have some association with our active and passive aspects of good feeling, pleasantness and comfortableness.

PS2-33

Colour Emotions for Antioxidant-Enriched Virgin Olive Oils

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ABSTRACT

Nowadays there is an increasing demand of new functional foods obtained from natural sources. A new antioxidant-rich extract from microalgae has shown a high potential as natural colorant in extra virgin olive oils keeping the natural properties of these products and adding positive properties (e.g. prevention of age-related macular degeneration) which may lead to a future functional food. This work looks for relationships between 9 specific colour emotions applied to a set of extra virgin olive oils which have been coloured by using a lutein and ß-carotene enriched extract from microalgae. 6 different olive oils have been coloured with this colorant obtaining a total of 18 different samples (6 without colorant, 6 with a concentration of 0.10 mg/ml and 6 with a concentration of 0.21 mg/ml). Colour of these samples has been measured using a Konica Minolta CS-2000A spectroradiometer in a lighting booth equipped with a D65 light source simulator positioned at the same place than the observers. 20 non-expert Spanish observers were asked to describe the colour appearance of the samples using 9 different pairs of adjectives (Aromatic-Odourless, Bitter-Sweet, Fresh-Rancid, Healthy-Unhealthy, Like-Dislike, Natural-Artificial, Spicy-Non spicy, Tasty-Insipid and Textured-Smooth). These specific adjectives were obtained after analysing 15 interviews with professional olive-oil-tasters from Instituto de la Grasa (National Research Council, Spain).

Results of spectroradiometric measurements showed that increasing concentrations of the colorant changed the colour of the sample towards a reddish hue. The microalgae antioxidant-enriched colorant changed the colour of the olive oils mainly in hue, in such a way that, on the average, more than 70% of the total CIELAB colour-difference between pure and lutein and ß-carotene enriched virgin olive oils was a hue difference. Torgerson's law of categorical judgment was applied to the results in our colour-emotion experiment showing that there is a high correlation between some pairs of emotions whose meaning is more related to colour preference (Fresh-Rancid, Healthy-Unhealthy, Like-Dislike, Natural-Artificial and Tasty-Insipid). Bitter-Sweet, Spicy-Non spicy,and Tasty-Insipid are not correlated with any other emotion. Finally, combining results from colour measurements and colour preferences we found that if the samples are too reddish its appearance tends to generate a dislike emotion. Therefore, virgin olive oils with high CIELAB hue-angles (i.e. greenish hues) seem to be the most appropriate candidates to be enriched by these extracts from microalgae.

PS2-34

A Study on Difference in Color Sensibility Judgment between Professionals & Non-Professionals

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ABSTRACT

In this study, we compared the contribution of hue and tone dimension to color sensibility judgment through subjective evaluation experiment using 43 sensibility adjective scales and 35 single colors, assessing both color professionals and non-professionals. The results were as follows.

Firstly, the color professional group displayed higher acuity for color sensibility judgment than the nonprofessional group, which is attributable to its higher discrimination capability for color stimulus differences and shift in sensibility. Secondly, hue and tone was defined as factors serving as judgment criteria for color sensibility, and their contribution was examined using repeated measures ANOVA. The results revealed that tone was more influential than hue in determining color sensibility, and the amount of its contribution differed between the subject groups. Thirdly, we applied a multidimensional scaling method (MDS) to analyze the structural dimension of color sensibility

on hue and tone in both subject groups. The two-dimensional MDS plots in the color professional group revealed the tone dimension much more clearly than the hue dimension, implying a stronger contribution of tone to color sensibility judgment. In addition, the complex concept of tone, the composite of brightness and saturation, was effectively confirmed through the two-dimensional distribution of tone factors along the axis 1 of "light and dark" and the axis 2 of "clear and dull".

Concludingly, tone dimension is more dominant than hue dimension in determination of various and subtle color sensibility, and this tendency was more apparent in the professional group. These findings are consistent with previous studies that suggest stronger contribution of tone than hue.

PS2-35

Age Effects on Garments Color Harmony

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ABSTRACT

In order to investigate the age effects on garments color harmony in two-color combinations, 300 color pairs were generated from 24 colors that uniformly selected from CIELAB color space. 59 observers with normal color vision aging from 20-79 were divided into two groups according to their ages: junior (20-45 years), and senior (46-79 years). They were encouraged to assess the garments color harmony of the above-mentioned color pairs presented as jackets and trousers on a vicenarian and a quinquagenarian model. The experiments were carried out on a well-characterized LCD monitor with a method of categorical judgment. The differences of color harmony for two age groups were studied by comparing the average and difference of chromaticity coordinates between the jackets and trousers.

The results from this study are summarized below:

1.For the same two-color combinations, all the observers had the higher response to the 300 garments color harmony on the vicenarian model than that on the quinquagenarian model, which means the same color assortment were appropriate for the vicenarian. The senior group was more tolerant than the junior group, especially for the assessments of the quinquagenarian model.

2.The relationship between the garments color harmony and the age advance was investigated, with the increasing of the age, the aesthetical values of garments color harmony for the observers had been varied and shown some different trends.

3.All the observers had the similar responses to garment color harmony on the vicenarian model and quinquagenarian model with the variations of the average chroma of jackets and trousers, it is believed that with the mean chroma values ranging from 5.0-20.0 (i.e., neutral colors), the highest score of color harmony will achieved.

4.For the lightness difference between jackets and trousers, the two age groups had no obvious difference. However, the color harmony is found to be the highest when the chroma difference or the hue difference between jackets and trousers is closed to zero.

PS2-36

Effects of Color and Aroma of Roasted Tea on the Predicted Taste and Palatability

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ABSTRACT

We can predict the taste of tea by the appearance and the flavor without drinking it. Thus it is useful to reveal the multimodal effect of color and aroma on the predicted taste and palatability of tea quantitatively.

In the present study, we focused on roasted tea, because it is one of the most popular teas in Japan and has a typical roasted flavor. The visual and olfactory stimuli were created from four roasted tea samples. Those samples were brewed two hours from 2, 6, 18 and 36 grams of tea leaves (a tea bag) and one liter of water, were evaluated by twenty participants in their twenties. They passed two screening tests, one for color perception (Ishihara Test) and the other for aroma perception (T&T Olfactometer). Each visual stimulus was in a glass, and each olfactory stimulus was in a brown bottle. The experiment consisted of three sessions. First, participants observed a visual stimulus without any olfactory stimulus (visual evaluation). Next, they smelled one olfactory stimulus without any visual stimulus (olfactory evaluation). Finally, they observed one of the visual stimuli while smelling one of the olfactory stimuli (visual-olfactory evaluation). The experiment was conducted in a dark room, where the illuminance on the desk was 300 lx under a D65 illuminant. Evaluated items were "intensity of color", "intensity of aroma", "predicted sweetness, bitterness, umami taste, deep flavor, roasted flavor", and "predicted palatability". As a result, it was revealed that not only color but also aroma of roasted tea effected the predicted taste and palatability.

Moreover, we tested whether the visual-olfactory evaluation (Z) can be explained by the linear regression of the visual evaluation (X) and the olfactory evaluation (Y) with weighting factors as the formula "$Z = aX + bY$". The results show that weighting factors of "predicted palatability" are (a, b) = (0.36, 0.41) and "predicted sweetness, bitterness, umami taste, deep flavor, roasted flavor" are (a, b) = (0.15, 0.56), (0.31, 0.57), (0.38, 0.61), (0.44, 0.55), (0.34, 0.71), respectively. Finally, we compared weighting factors of roasted tea and those of green tea which was calculated in our previous study. Those results suggest that olfactory weighting factor of "predicted palatability" in the case of roasted tea is slightly larger than that in the case of green tea ((a, b) = (0.51, 0.49)).

PS2-37

A Study of Relationship between Physical Value and Psychological Value in PCCS

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ABSTRACT

In colorimetry, color is classified on the basis of three attributes: hue, value, and chroma. These are physically independent, and many color order systems have adopted them; for example, the Munsell system. However, these attributes are not psychologically independent. For instance, in the Helmholtz-Kohlrausch effect, it was observed that lightness perception is affected by chroma. Therefore, it indicates a psychological interaction between value and chroma. Practical Color Co-ordinate System (PCCS) is a color order system developed in Japan, and it comprises three attributes: Hue, Lightness (value), and Saturation (chroma). Moreover, PCCS is characterized by the tone, which is a combination of Lightness and Saturation. Many studies have included three or four dimensions of color image. Our previous study by factor analysis identified two dimensions of color: activity and potency. These factors corresponded with the physical value of color, i.e., potency of Lightness and activity of Saturation in PCCS. The purpose of this study is to examine the effect of psychological Lightness and Saturation on color image by analyzing its tone. This study adopted two methods. First, we investigated the dimensions of the color image; second, we measured the psychological Lightness and Saturation of color. Further, we examined the relation between the dimensions of color image and psychological Lightness and Saturation using a scanning electron microscope (SEM). The stimuli used 12 tones (vivid, bright, strong, deep, light, soft, dull, dark, pale, light grayish, grayish, dark grayish), five Hues (2R, 8Y, 12G, 18B, 22P), and achromatic colors. These were classified into four types: (1.) tone stimuli, each tone consisted of five Hues in a circle; (2.) Hue stimuli, each Hue consisted of 12 tones in a row; (3.) gray scale, five steps of achromatic color in a row; and (4.) single color stimuli. The subjects watched stimuli and evaluated them by seven point scales of Semantic Differential method and Visual Analog Scale. The stimuli were presented randomly. The environment

of experiment was a classroom of university and the experiment was taken under the fluorescent ight. As a result, when psychological Lightness and Saturation are integrated, their relationship with the impersonal dimensions will be evident. The findings of factor analysis can be indicated by three factors similar to Osgood's three factors. Furthermore, the correlation relationship would be obvious between factor scores and physical values. SEM is performed to investigate these results, and consequently, the relational model of physical value and psychological value would be constructed.

PS2-38

Psychological Effects of Meal Tray Color on the Visual Palatability of Meals among Individuals with Low Vision – the Effect of Brightly Toned Colors

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ABSTRACT

Introduction:

According to reports by the World Health Organization, 347 million people worldwide have diabetes. In such individuals, a lack of control of dietary intake can lead to serious complications, such as diabetic retinopathy, which leads not only to low vision, but also blindness. Although cooking and eating for dietary control under low vision is difficult, most color schemes, which represent an important factor in appetite, in tableware made for individuals with low vision only come in combinations of black and white. This study examined the psychological effects of meal tray color on visual palatability of meals for low vision.

Methods:

1) Color conversion method

Meals on trays that created a good color scheme together (not including dishes on the tray) were selected using the semantic differential (SD) method from 218 meals served for approximately 2.5 months in a nursing home in Japan. The colors of the trays with the meals found to be most appealing by the SD method were converted to 6 bright tones (b2, b4, b8, b12, b16, b24 on the Practical Color Coordinate System) using Photoshop on a liquid-crystal display (LCD) screen. The legitimacy of color conversion was confirmed using a brightness meter.

2) Investigation methods

Participants comprised university students (mean age, 21.7±0.76 years; 309 females, 118 males) who sat in front of an LCD screen onto which the 10 colors of trays were projected. After viewing, subjects answered a questionnaire. All experiments were performed in a room with a fixed fluorescent lamp on the ceiling. Results were compared between two groups: a low-vision group in which subjects wore low-vision simulation glasses (n=30); and a healthy group without glasses (n=31). The scale of the tray pictures was 60%. Illuminance on each table was 505±11.4 lx, room temperature was 25±1.3 ºC, and humidity was 57±14.7 %. The questionnaire comprised the following 3 sections: attributes; physical and/or mental condition; and image of the dining space. Images for each tray color were defined by the SD method, using 36 antonymic adjective pairs. All subjects took part in the experiment at least 1 h after eating.

Results:

By using factor analyses, two components, "activity" and "relaxation", were extracted. Tray color b8 was positive for both components in terms of visual perception for both low vision and healthy subjects. In addition, b8 was evaluated high visibility than other colors.

Conclusion:

Tray color b8 was shown as the most useful color for visual perception, universal color design, and comfort among 6 bright tone-colored trays.

PS2-39

A Comparison Between the Impact of Short and Long Wavelengths of Light on Sleepiness and Mood

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ABSTRACT

Since sound sleep is indispensable, for health of body and mind, the increasing number of people who are suffering from sleep problems is a concern, raising questions about how to promote high-quality sleep. One of the factors thought to be associated with high-quality sleep is the light illumination of the bedroom. Specifically, three characteristics of the light-dark signal, that is the timing, light intensity and light wavelength, are important for circadian entrainment, which is associated with the sleep and alertness rhythm. Many studies, which have compared long wavelength light (red light), with short wavelength light, have reported that the light having short wavelength (blue light) stimulates the circadian rhythm most, impacting alertness and reducing the quality of sleep. Moreover, blue light exposure has also been shown to be a factor contributing to mood disorder.

However, according to an investigation conducted by Travelodge, one of the leading hotel chains in the UK, sleeping in a blue bedroom is far more conductive to a good night's slumber than sleeping in a red bedroom. Several studies have reported that red is the color which stimulates the sympathetic nervous system (SNS) most, whereas blue activates the parasympathetic nervous system (PNS), producing a calming effect. These studies appear to contradict the findings noted before.

Therefore, in order to clarify which condition is indeed better for sleep, a red light condition or a blue light condition, a study design based on the experimental method is proposed. As a preliminary step, the present study compares the impact of short and long wavelengths on sleepiness and mood using both the questionnaire method and a behavioral task.

A within-subject experiment was designed. Subjects were exposed to two lighting conditions, a red lighting condition presented by a red LED light (spectrum peak at 630 nm) and a blue lighting condition presented by a blue LED light (spectrum peak at 462 nm). Sleepiness was measured by visual analog scale (VAS) questionnaire. Mood was measured by profile of mood states (POMS) questionnaire.

Results from POMS showed that Total Mood Disturbance (TMD) scores and Vigor (V) scores had marginal differences in the bedroom of short wavelength. In the case of results from VAS, compared with before and after the light exposure, a significant increasing trend was found in sleepiness, which to some extent reflected the impact of light on the sleep. However, no significant difference in sleepiness was found between short and long wavelengths.

PS2-40

Experimental Study of Common Factors between Impressions of Wall-Paper Colors and Sounds in Living Environments

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ABSTRACT

In our daily life, psychological impressions are formed through multiple sensory modalities rather than a single sensory modality. The experience of such cross-modal perception is quite natural and common to us because two or more different sensory modalities usually interact in our brain. Furthermore, people often express their impressions in association with those of colors. Therefore, the comprehension of the relationships between the impressions derived from multiple sensory modalities and the impressions of visual information, especially colors, can serve as an effective approach to the clarification of the structure of the impressions derived from multiple sensory modalities. So, in this research, we, through experiments, investigated the common factors between the impressions elicited

by the change of wall-paper colors and the impressions elicited by the change of sounds in living environments.

The total number of the subjects who participated in the experiments was 30 undergraduate and graduate students (12 males, and 18 females, ages: mean=21.8 years, SD=1.34). The experimental stimuli were as follows: 1) A model of a living room (Width 500mm x Depth 400mm x Height 300mm) with all of its miniature interior materials (three sofas, a table, and a curtain) being white. Wall-papers were 9 different colors of PCCS (Practical Color Co-ordinate System): pale tone and grayish tone x 2R, 8Y, 12G, 18B and white. 2) Sound stimuli: 4 pieces of music of our own computer-software produced composition with two different keys (C in high and low) at two different tempos (BPM=120, 210). The model was illuminated by Panasonic natural white.

Looking into the living room through an observation window of the model, the participants were asked to rate each stimuli by seven-point scale in accordance to a semantic differential (SD) method. In our experiments, 17 adjective-pairs were used. The evaluation was followed by free comments (about the first impression, the positive or negative feelings, the extent of comfortableness and so on) together with some verbal questions (feeling free or not, favorite and disliked colors and so on).

The study comprised three experiments: Firstly, the participants were asked to evaluate psychologically each living-room model by the SD method, and provide free comments. Secondly, they were asked to evaluate each of the four pieces of music by the SD method. Finally, they were to evaluate by the same SD method each model of a living room while listening to one of the four pieces of music.

The data obtained in the three experiments were analyzed independently by the SD method (Likelihood method, Promax rotation). Two factors showed up in the analysis results of all the three experiments. The first factor included the scales “quiet”, “warm”, “soft”, “light”, “cheerful”, “ornate”, and so on, and the second factor included the scales “ordinary”, “calm,”, “familiar”, and so on. Hence, it is possible that these two factors are the common factors between the impressions of colors and those of sounds with regard to the creation of a comfortable living-room.

PS2-41

The Investigation of Factors Influencing the Impression of Color Harmony

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ABSTRACT

Color harmony has been systematically investigated since 1956 at Budapest using specific pattern samples. Up to now, there are three known color harmony models proposed by Ou et al. (abbreviated as the Ou), Szabó et al. (as the Szabó) and Kuo (as the Kuo). To quantify the impression of color harmony, Ou et al. developed a CH formula for two color combinations. Szabó developed a CH formula for three color combinations and a harmony rendering index (HRI) quantifying the change of the value of CHF for certain test color sample combinations under the test light source. Kuo developed a CH formula via adding textile pattern samples, color images of fashion apparel with two and three color combinations, and using a psychophysical method of magnitude estimation instead of previous psychological method of category judgment. However, the above three models still cannot have good agreement with their predictions and visual test results of color harmony. The current findings indicated that factors influence the accuracy of color-harmony predicting models need to be further examined.

PS2-42

The Hidden Image – A Strategy to Put an Unwanted Phenomenon in its True Light

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ABSTRACT

In the everyday we are surrounded by images and the plethora of visual material is overwhelming us. We do not anymore look properly at images and we assume that what we see is correct. We do not doubt our sight. We trust the work of our brain, which translates the information received by our eyes. We do not expect that the same image could change its look and that it could appear with different colours.

This proposal depicts the journey of the exploration of the physical colour phenomenon called metamerism, where a colour pair looks even in a given light situation, but may appear different in a changed light source. In the field of colour and colour management most practitioners aim to avoid metameric colour pairs, as it is seen as a problem so far.

By contrast, the fascination of the subtle colour change and the interest to work with this "error", uncovering the potentiality of something that has not previously been appreciated, is a main driver of this research. I argue, that everybody knows this phenomenon, but nobody is really conscious about it.

This research investigates the creation and steering of metameric pairs of colours and their impact upon viewers. Yarns, as the basic material of the fabrics, have intentionally been dyed to be metameric. Knit has been chosen as the medium to bring together the metameric yarns and to create therewith images. The fabrics, thereby created, change colour depending on the switched on "white" light source and they are revealing hitherto unnoticed visual contrasts. This leads to a new consideration of a phenomenon, which has been seen as problematic so far. The aim is to give visibility to a phenomenon of the every day.

The creation of the knitted images is driven by the necessity and importance of subtle wonders in this day and age. Light breathes life into the colours of the fabrics and the images unveil the phenomenon offering to the audience this wonderful magic of the relativity of colour perception.

The interaction of light and colour creates different views of one image and through these artworks metamerism becomes experiencable and the vitality of colours becomes reality.

PS2-43

Does Colour Really Affect Pulse Rate and Blood Pressure?

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ABSTRACT

Colour can profoundly affect our physiological and emotional states. There is anecdotal evidence that some colours can make people feel more relaxed and can even affect their pulse rate and/or blood pressure. However, there is surprisingly little robust evidence for this particular effect. One reason why it may be difficult to provide compelling evidence is that the effects may be quite small and the variation between observers may be quite large; this means that it is difficult to find a statistically significant effect. In this paper a psychophysical experiment will be described with a large number (>100) of participants. The aim is to provide strong evidence that colour does affect human physiology in the way anecdotally described or to provide evidence that no such effect exists.

In order to address the research question the authors have constructed a personal colour environment (PCE) for the experiment in which participants can be immersed. Chromatic lighting can be used to illuminate the PCE of various hue but with consistent chromaticness and illuminance. A previous study by the same authors suggested that there was no statistically significant effect of colour on either pulse rate or blood pressure. However, a statistical analysis of power from a previous study suggests that there was a possibility of a type I error and has been used to define the number of participants in this new study.

PS2-44

Effects of Font Size on Visual Comfort for Reading on a Tablet Computer

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ABSTRACT

There are more and more people using tablet computer displays for e-reading, it is important to know how users use these devices effectively and avoid any visual discomfort. The previous study given by Iain Darroch shown that designers of interfaces for handheld computers provide fonts in the range of 8-12 point to maximize readability for the widest range of users. The equipment was HP iPAQ hx4700 which has a 65,000 colour TFT screen with a resolution of 640x480 pixels was used to present the text. The resolution of HP iPAQ hx4700 is smaller than the resolution of tablet computer such as iPad 2 or iPod touch 4. Our study aims to investigate the effect of display size(font size) for older and young observers reading on a tablet computer.

To investigate the effect of display size on visual comfort for e-reading, two psychophysical experiments were conducted. Based on the 5 achromatic colours, 20 text-background combinations were generated, considering both positive and negative polarity conditions. The pair of document layout was composed by 2 text-background combinations from 20 text-background combinations. This resulted in 190 paired comparisons. During Experiment 1, 20 older and 20 young observers were presented with 190 pairs of document layouts on an iPad 2. During Experiment 2, 20 older and 20 young observers were presented with 190 pairs of document layouts in a simulated iPod touch 4 size also shown on the iPad 2. Each document layout was presented on the same text, the only difference being the lightness values of the text and of the background for the two document layouts. Each observer was asked to pick one of the two layouts, of which the observer felt more comfortable to read the text. The font size of Experiment 1 was bigger than the font size of Experiment 2. The display was situated in a darkened room, with the only light source coming from the iPad 2. The display peak white had a luminance value of 397.34 cd/m^2, with CIE chromaticity (x, y) = (0.3005, 0.3115). The viewing distance was around 300mm between the observer and the iPad 2, which was placed with a tilt angle of 15 degrees against a desk.

The scale values for the observer response were determined using the paired comparison method. The results of Experiment 1 and Experiment 2 show that older observers tended to prefer strong text-background lightness difference in a document layout, while young observers tended to prefer moderate lightness difference. The scale values from iPad 2-size(Experiment 1) to iPod touch 4-size(Experiment 2) for older and young observers shown that the difference of visual comfort between black background and others background is increased. However, the difference of visual comfort between white background and others background also increased for young observer. This phenomenon for young observers was different from the scale values for older observers.

PS2-45

Influence of Spectral Component of White Light on the Discomfort Glare — Contribution of Image and Non-image Forming Pathways —

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ABSTRACT

Discomfort glare is remarkable issue on novel light sources such as solid state illuminating light sources (LEDs and OLEDs). This issue may be due to various factors. Optical characteristics such as flux distribution, size and uniformity of the light-emitting parts is one of crucial factor and they have been discussed to extend conventional discomfort glare estimation equation known as UGR to be available for novel light sources.

In this research, we focused on the fact that solid state light sources differ greatly in spectral

characteristics from conventional light sources. We conducted subjective evaluation experiments using metameric lights with different spectral characteristics and the same photometric value to find out whether there are differences in discomfort glare.

A set of metameric white light was used to investigate the influence of spectral context to the discomfort glare. Six spectral distributions of metameric white lights were designed based on principle of compositions of monochromatic spectrums. Two of test lights consist of two monochromatic lights which have a peak in different wavelength and three of test lights consist of three monochromatic lights. As conventional light, spectrally broad light was also employed. Chromaticity of the each test light was fixed to x = 0.3127 and y = 0.3290 in CIE1931 2deg chromaticity diagram and luminance was fixed to 18,500 [cd/m^2].

Experiments were performed in dark room. Spectrally programmable light engine was used for presenting test lights. Four adults man were participated. After dark adaptation, test light was presented in 3 [sec]. Observers were instructed to fixate test light and report the evaluation as discomfort glare scale (1 to 9, 9 in worst, known as conventional discomfort evaluation method) after test light had turned off. Six test lights were randomly evaluated in one block. Each observer was tasked six blocks in total. Here, first one block was considered as training task, evaluations of last five blocks were employed as candidates of analysis.

Results showed that although each luminance of test light was same, discomfort glare have a clear dependency to spectral distribution of the test lights. Especially, excitation quantity around 500 [nm] had been correlated with discomfort glare evaluation.

Therefore, we investigated the contribution of ipRGC as non-image forming pathways and rod as image-forming pathways to the discomfort glare. Following the composite action spectrum which was proposed by Rea (J. Pineal Res., 2002), quantity of ipRGC stimulation for the each light was calculated. Also, quantities of rod stimulations were calculated. Then, we found that correlation between quantity of them and psychophysical evaluation of discomfort glare.

These results suggest that discomfort glare could be affected to both image and non-image forming pathways.

PS2-46

Low-chroma Colors Suppress Luminance-driven Brain Activation Measured by fMRI

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ABSTRACT

In observing the visual scene, our attention tends to be captured by the particular part of the scene which generally has an outstanding visual feature structured by luminance and color patterns. In this study, we focused on effects of saturation (chroma) of the visual target in visual information processing. We investigated affects of target's saturation to neural mechanism through brain activation measured by fMRI.

We presented 10 patches filled by 10 hues (5R, 5YR, 5Y, 5GY, 5G, 5BG, 5B, 5PB, 5P and 5RP on Muncell color system) on the background of achromatic pattern consisting of more than 700 achromatic oval patches. The diameter of the patch was 3.0 degree and the center of the circle was 6.2 degree from the central fixation point. The chroma of patches were set at one of 4 levels (6, 4, 2 and 0). Levels 2, 4 and 6 corresponded to Munsell chroma in these hues and the level 0 corresponded to an achromatic condition. In experimental sequences in fMRI scanning, one visual stimulus as described above and its one-pixel-based scrambled pattern were altered in 1 Hz. Subjects simply fixated at the center of the screen during the trial. Each trial lasted 15 sec and an interval of 15 sec was inserted between trials for resetting the brain activations. In the first 5 sec of the interval, subjects were asked to perform an easy perceptual task to confirm awake of subjects. 13 subjects participated in the experiment.

We calculated brain activations during the observation of visual stimuli in visual cortexes (V1, V2, V3, V3A/B, hV4 and LO (Lateral Occipital) 1). The results showed that brain activations were significantly lower in the conditions of chroma-2 and 4 than achromatic condition, in most of visual cortexes. In the chroma-6 condition, brain activations were also lower than achromatic conditions

although there was no significant difference. It seemed that the brain activation for achromatic background pattern was dominant because the regions of color patches were relatively small compared to the region of background in visual stimuli. It introduced the hypothesis that brain activities caused by chroma 2~6 stimuli were not reflecting the strength of color (in terms of saturation) but reflecting the achromatic (luminous) stimulation. Thus, we supposed that color patches suppressed the brain activations driven by achromatic background and the amount of the suppression was larger in lower-chroma colors.

We conducted the control experiment to confirm that the difference of brain activation in the result of our main experiment was not due to difference of brain activation driven directly by color patches. In the control experiment, we removed the background pattern from stimuli used in the main experiment and other conditions were identical to the main experiment. As a result of the control experiment, brain activity showed no significant difference between conditions of chroma 6, 4, 2 and 0 except V1 response. Thus, it has been proved that brain activities caused by color patches themselves could not explain the result of the main experiment. It means that the result of the control experiment supported our hypothesis.

PS2-47

A New Evaluation Method Using the 100-hue Test and Age Trends in Color Distinction Ability

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ABSTRACT

It has often been noted that sight becomes yellowish with aging due to the lenses of the eyes taking on a yellow hue. As a result, the ability to distinguish color is diminished. This can cause missteps and failures of visual recognition, which could lead to accidents, collisions, or falls. But the degree of the decline in color distinction ability varies among individuals. Therefore, it is important to be able to determine how advanced the degree of decline is. There are several experimental methods to evaluate color distinction ability. However, they are inconvenient for individuals wanting to learn their status quickly.

This study proposes a new way using the 100-Hue Test. The 100-Hue Test is used to check the ability to judge the differences between subtly different colors. The 100-hue test requires calculating the error scores of four trays and estimates color distinction ability by the size of the error score values. However, while the sizes of the error scores can be compared relatively, the numerical value of the error score is insignificant.

This study designs a new evaluation index using the 100-Hue Test. This index digitizes color distinction ability using probability and statistics theory. A result of the test of 34 subjects in their twenties to seventies was analyzed using this new evaluation index. It was found that color distinction ability in the G - BG - B area and the RP - P area falls conspicuously during one's fifties. Individual variation was found to be large, with some subjects in their fifties to seventies having the same distinction ability as those in their twenties.

PS2-48

Study on Image Statistics when Color Attracts Human Attention

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ABSTRACT

Computational models of human visual attention predict attended locations in a visual scene using bottom-up, image-based saliency visual features such as orientation, color and intensity (Itti et al., 1998). These features are assumed to contribute equally to construct a single saliency or conspicuity map. A previous study applied a machine learning technique in order to seek optimal weights of the

features, and showed that the feature map for orientation successfully captures human overt attention (gaze location) compared with the other low-level features (Zhao and Koch, 2011). Although the result suggests the dominance of orientation for the deployment of attention based on low-level features, it has not been clarified whether relative efficiency among low-level features is always constant on individual images. First, we computed orientation-based and color-based saliency map of around 500 natural images with each gaze map taken from MIT dataset (Judd et al., 2009), and evaluated prediction accuracy by means of the area under the curve (AUC). Our results showed that orientation-based saliency outperforms color-based saliency on average (AUC scores are 0.69±0.12 for orientation, 0.60±0.15 for color; mean±SD), which is consistent with the result of the previous study. The images were ordered based on the difference of AUC scores between color and orientation so that we classify the images into two categories: color-dominant and orientation-dominant images. For around 25% of the images, color information was more effective than orientation information to predict gaze locations. The top six of the color-dominant images tended to contain one or two large objects of which color and luminance are different from a background. The top six of orientation-dominant images tended to have monochromatic objects as salient image features. We also investigated any common characteristics of the images that lead the better performance of color-based saliency, using four statistics (mean, variance, skewness and kurtosis) of all images in CIE *L*a*b** color space. The result showed that the better performance of color-based saliency was obtained with larger L* variance. The finding suggests that image statistics may provide important information of saliency of color and orientation feature maps.

PS2-49

Prior Knowledge Modulates Peripheral Color Appearance

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ABSTRACT

Color perception diminishes with increasing eccentricity in the visual field. Here, we investigated peripheral color perception with a painting method, asking how prior knowledge affects color appearance. A professional artist was presented with complex, cluttered images in the visual periphery. The task was to paint as accurately as possible how an image appeared. Eye tracking assured that the image was only viewed in the periphery: When the participant fixated a central fixation dot the image was shown, otherwise, a mask was presented. After finishing a painting, the image was shown foveally for a short time to visually inspect and acquire knowledge about it. Next, the same image was presented at the same peripheral location and painted again. The paintings resulting from the two presentations showed strong differences in regard to color. Salient color regions in the images that were not depicted during the first presentation, were depicted during the second presentation. Importantly, other features, such as diminishing spatial detail with eccentricity were similar in both conditions. Our results indicate that prior knowledge of peripheral targets strongly shapes perception. We show how vague, peripheral color appearance is influenced by top-down processes, and discuss our findings in light of current theories of crowding.

PS2-50

Decision of Validness in Custom Color Name of JIS Z 8102

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ABSTRACT

Generally, color names tend to be used for daily communication in color. Especially in Japan, “Systematic” and “Custom color name” are used based on JIS Z 8102 (). Custom color names have

origin in plant, material, food and so on. But it was not revealed whether each custom color name is used accurately or not.

To clarify this question, 3 indices "Color difference between a given standard color of JIS Z 8102 and subject's choice for it in CIE L*a*b*", "Familiarity of color name" and "Imaginableness of color name" were acquired from color choice experiment and questionnaires to subjects (2009, Yoshizawa et al). These indices lead new 2 parameters "Degree of recognition" and "Distance in color space" in each color name for decision of how much recognition in each custom color name.

In another aspect, distinguishes between in custom color names included basic color – ex. Chinese red, Chartreuse Green, cobalt blue and so on - were clarified, and valid color names were decided in each group with included basic color based on Berlin & Kay's 11 color words (2009, Yoshizawa et al).

Against this aspect, the aim of this research is to reveal validness of Custom Color Name in all 267 custom color name of JIS Z 8102（except of color names "Gold" and "Silver"）.

First, cluster analysis makes some color name clusters from data of color choice experiment in each 267 color names (2009, Yoshizawa et al), and ANOVA (analysis of variance) divides more detail clusters in each.

Finally, representational color is decided based on "Degree of recognition" in each cluster and validness of each custom color can appear.

Based on this result, I hope we have an opportunity in exist of each custom color name.

※ JIS Z 8102（"Names of non-luminous object colours" from Japan Industrial Standard）

PS2-51

Evaluation of Color Appearance under LED and OLED Lighting Based on the Data Obtained by a New Color Category Rating Method

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ABSTRACT

Technologies of solid-state lighting, such as light-emitting diode (LED) and organic electroluminescent lighting (OLED), are progressing rapidly in recent years. LED lighting is now widely used in our living environments. There are still arguments, however, about color appearance under these lighting environments.

Experiment 1:

In this study, we conducted the experiment (EXP.1) to evaluate the appearance of colors under white LED, OLED and fluorescent lamps using color chips systematically selected from the Munsell color space[1]. To evaluate color appearance, we introduced a new color category rating method that was extension of the method reported by Uchikawa et al. [2] in an important way to obtain more detailed description of color appearance. Subjects answered color appearance of a chip by giving up to three colors out of 11 basic color terms (red, blue, green, yellow, purple, pink, orange, brown, black, gray and white), and also rated the weight of each of the selected colors in total of 10 points. After adapting to a given illuminant (FL, LED or OLED) of 500 lx for 5 minutes, a subject responded with the color category rating method for each of 146 color chips presented on the gray background. The size of color chips from the subject was about 2 deg. Each of the subjects repeated twice for each illuminant condition. 10 subjects (University students) participated in the experiments.

The results of the experiment 1 showed that the color category rating under each of three illuminants were similar generally, however, there were clear differences in some parts of the color space.

Experiment 2:

To know quantitative changes of the color appearances, we considered possibility to transform color category rating data to elemental color rating data. Then we carried out the additional experiment (Exp.2) in which color appearance was measured by the elemental color naming method. In the experiment 2, the subjects described color appearance by giving achromatic rate (black/white), followed by chromatic rate (red/green, yellow/blue) 100% in total. The number of the Munsell color

chips tested in the experiment 2 was 76. Other procedures and conditions were the same as in the experiment 1.

The results of the experiment 2 also showed some significant differences of the color appearance in each of three illuminants.

Discussion

Relationship between the color category rating responses (Exp.1) and elementary naming responses (Exp.2) was analyzed with multiple regression analysis; explanatory variables were rating responses for 11 categories and objective variables were elementary naming responses for 6 elemental colors. The results of the analysis clearly showed that regression models based on the color category rating well explain the elementary naming response, indicating the color category data can be transformed into the elementary naming responses.

We will discuss the evaluation of the color appearance under the LED and OLED illuminant conditions based on the data obtained by the color category rating data. In addition, usefulness of the color category rating method will be considered based on our findings.

[1] The part of the experiment 1 was reported by Shoji, Y. et al. (2013), Proc. of the 1st Asia Color Association Conference, 207-210
[2] Uchikawa, K. et al. (1994), J. Illum. Engng. Jpn., 78(2), 83-93

PS2-52

Influence of Position of Colored Panels to Entire Pattern‘s Visibility.

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ABSTRACT

Visibility, including capturing attentions, to an object is strongly affected by color of the object. The effect of color to the visibility has a certain regularity like the amount of chromatic difference between the object and white under the illumination used in that visual environment as reported (Shinomori et.al. APCV2014). In realistic scenes, however, other factors like placement of objects, visual environment and so on should also influence the visibility. Under this argument, local colored parts and their position should interact each other and the best visibility should be determined as the combination of the color and position. In this study, we investigated the relationship between colored panels and their position to obtain higher visibility using simple but complete set of patterns.

In the experiment, we used 36 patterns in which two panels in 3 X 3 gray panels were replaced to colored panels in equal luminance. We used the Thurston’s paired comparison method, in which randomly-selected two patterns were placed side by side and compared by an observer under the criterion of “visibility”. We calculated z score of each pattern which is showing the position in the normal distribution function from selection rates (0~1) for all combinations. Plus one of z score means the data higher than the average in one standard deviation in the normal distribution function.

In the result, for example, using two red panels, the patterns with higher z scores (more selected patterns) had a common feature; two red panels were not neighbored and placed in different rows and columns. On the contrary, in the patterns with lower z scores, two red panels were neighbored in the same row or column. This kind of regularity can be more complex in the case that two colored panels have different colors. The entire visibility will be influenced by the combination of two colors, in which one color is much more visible than the other, or two colors have almost the same visibility. We have not yet obtained the theoretical model to predict the visibility and more trials in more combinations are currently going on.

PS2-53

A Color Coordination Support System Based on Impression from Color and Readability of Text

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ABSTRACT

Readability of color scheme is one of important factor at general text design including graphic design and web design. Colors and color schemes owe unique psychological effects. In general text design, color choice should consider these unique psychological effects. However, this considerable color choice must need high degree of skills. In present study, authors tried to construct semiautomatic color coordination support system based on psychological color theory. Color coordination support system was able to nominate text colors that were specified by background color. Nominees were based on psychological color theory and readability. Readability of color schemes were measured and formulated from subjective evaluation experiments. This system is expected to facilitate color coordination in color design work for easily manipulating colors.

PS2-54

Study on Visual Recognition of Specula Reflection about Silk and Cotton Textile

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ABSTRACT

The various texture and design of fabric is created by combined fiber material, spinning, weaving and finishing effects. Especially, silk and cotton fabrics are the most popular and typical cloth in human life, and also there were a lot of represented by drawing or painting on the arts. Basically, visual recognition of silk and cotton textile is very interesting subject.

In this study, optical property of textile was measured, and applied human visual assessment by computer graphics to clarify the mechanism about visual recognition of silk and cotton textile. The measuring samples were 19 white or non-dyeing textiles included silk, cotton, polyester materials, and these were plain and twill weavings. Sample was stretched on 20cm diameter cylinder surface with tensile force to sense reflectance profile with various illuminant and detect optical dimension, and measured by gonio-photometric spectral imaging system composed liquid crystalline tunable filter and white LED illuminant, Peltier cooling CCD monochrome image sensor. Illuminant direction was 15 and 45 degree from normal direction, and detect direction was normal against sample. In this case, detect angle range against specula direction of sample sureface was around -30 to +120 degree, and imaging resolution was 180 dpi.

After measuring, spectral image at 550nm wavelength of each samples were anarized and calculated skewness and deviation profile of optical dimension. To analisys of visual recoginition, the human visualize assessment test was applied magnitude estimation method combined polar coordinates to apply two different parametric objects, angle was meaning of material type that is silk or cotton feel, and distance from origin was meaning of textile feel. The display device were presented monochrome visual stimulus with this coordinates. The images of this experiment were created from metric profile and combined with typical short fiber texture like a cotton broad cloth and typical long fiber texture like a silk taffeta cloth, and variables were intensity of specula profile and texture images. The display device was used 31.5 inch size 4K monitor model U32D970Q made by Samsung, and resolution was 208dpi. And illuminance spectrophotometer CL-500A made by Konica-Minolta was used measuring of display device spectral property.

As the result of this study, the boundary area of textile feel, and also silk/cotton material feel were calculated. The silk feel was approximately related with intensity of specula profile, and textile feel was approximately related with intensity of texture. The detail result was shown in this study.

PS2-55

An Experiment on Color Differences Using Automotive Gonioapparent Samples

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ABSTRACT

A panel of 9-11 observers with normal color vision has assessed a set of 61 color pairs in a multiangle color cabinet using a gray scale method. The main goal was to test the potential relationship between perceived lightness differences and lightness flop. The samples in our color pairs were nearly achromatic (C^*_{ab}<10) and with gradual changes of lightness flop in the range 0.5-4.0 CIELAB lightness units per degree. The average color difference in the color pairs was 3.0 CIELAB units. The percentage of lightness difference in the total color difference was above 85% in all color pairs, with an average value of 93.7%. Observers' variability in our experiment was low, with an average standard deviation of visual differences of 0.6 CIELAB units, or an intra- and inter-observer variability of 15.4 and 17.5 STRESS units, respectively. The CIEDE2000 color-difference formula provided the best predictions of our visual results with a STRESS value of 27.4. However, the predictions made by CIEDE2000 and a set of 11 different advanced color-difference formulas were not statistically significant different, with their STRESS values changing in a short range from 27.4 to 33.0 units. Our results show no clear relationship between perceived lightness differences and lightness flop, perhaps because the perceived lightness gradients in the samples in our experiment were small. None of the weighting functions for lightness proposed by recent color-difference formulas (e.g. CMC, CIEDE2000, CAM02-SCD, OSA-GP-Euclidean, AUDI2000, etc.) was particularly useful to predict the results of our visual experiment. However, power functions seem an appropriate option to improve the predictions of current visual results. Specifically, an exponent 0.55 in the CIEDE2000 and AUDI2000 formulas provided STRESS values of 18.5 and 18.3 units, respectively, which are considerably lower than the original ones and close to inter-observer variability.

PS2-56

Legibility of Printed Thai Letters Comparison on Young and Elderly

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ABSTRACT

Elderlies' vision deteriorates by cataract when they are aged. Printed labels represent visual environment and have been found to be expressed by so small letters, which are too difficult for elderlies to read. Design of labels and sign consist of fonts and colors. Thai letters are unique in shape and composition, and can have effect on legibility. The proper color-pairs used for combination of fonts and backgrounds are also needed to guarantee highly legible for efficient vision. This research aimed to compare the legibility of printed Thai letters for young and elderlies in terms of different background contrasts and different color-pairs under normal daily situation and illumination. Subjects experimented with adjustment method to find out the legibility of letter charts capable for correct reading. Three achromatic charts of black letters on White, N5, and N4 backgrounds were used for monochrome chart. Eight color-pairs charts: 4 of Red, Green, Yellow, and Blue letters on white background, and another 4 of Red, Green, Yellow, and Blue letters on black (N5) background, were used for color contrast legibility. The categorical judgment method also used for judging the seeing comfort of other color combination among young and elderly subjects. The combination of color-pairs of letter-background consist of (1) Red-White, (1) Green-White, (3) Yellow-White, (4) Blue-White, (5) Red-Black, (6) Green-Black, (7) Yellow-Black, (8) Blue-Black, (9) White-Red, (10) White-Green, (11) White-Yellow, (12) White-Blue, (13) Red-Blue, (14) Green-Blue, (15) Yellow-Blue, (16) Red-Green, (17) Blue-Green, (18) Yellow-Green, (19) Green-Red, (20) Yellow-Red, (21) Blue-Red, (22) Red-Yellow, (23) Green-Yellow, (24) Blue-Yellow. There were 15 young (age 20-40 years) and 15 elderly (age 60-80 years) Thai subjects participate in this experiment.

The 11 letter charts in different colors and backgrounds each contain 24 lines of Thai letters varying in sizes that were logarithmically even distributed. The viewing distance of 1.2 meter with natural lighting situation was used for this experimental illuminance. The 24 letter labels in different

color combination for categorical judgment were made in same letter size. The result should show that the legibility of elderlies worse than the young by some certain degree. The color may also affect the legibility of young and elderly differently. And reading comfort among each color combinations should give different result among young and elderly.

PS2-57

On the Perceived Brightness of Whites

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ABSTRACT

Whiteness and whiteness rendering of objects have been topics of considerable interest. One of the most fascinating results in the perception of whites is the fact that objects with a slight bluish tint appear whiter than object with a neutral reflection. This fact contributed to the widespread use of fluorescent agents in white objects that transfer energy from the violet and ultraviolet to the visible blue part of the spectrum, thus producing a slight chromaticity shift towards blue. An interesting side effect of the increased whiteness is the feeling of increased luminance of the white surfaces. Looking at the CIE Whiteness formula, one can compute a ratio between the increase of luminance and change of chromaticity that result int the same increase of perceived whiteness. This result, however, holds for two object under the same illuminant.

In this work, we explore the relation between the perceived whiteness and perceived brightness of light sources. In a simple setup consisting of two white boxes positioned side by side, two sets of two dimmable light sources were positioned. The spectra of the sources were selected such that the resulting difference in the chromaticity under the different spectra was 0.007 du'v'. One, the reference, rendered the white objects in the scene on the black body line, while the other below it. The illuminance produced by the reference light source was kept constant at one of the three test levels (150 lux, 300 lux and 500 lux). Using a staircase procedure the illuminance produced by the other light source was matched on the perceived brightness of the simple scene. At every step in the staircase, the participant had to decide which of the two simultaneously viewed scenes appeared brighter. The position of the spectra in the left and right scenes was balanced and all the staircases were interleaved. Additionally, two staircases with the same spectrum in both scenes were added to check for the measurement error of the method.

The results of 18 participants show a surprisingly large effect of the relatively low chromaticity change on the perceived brightness. The illuminance level at which the whiter scene looked equally bright with the reference was found to be on average 20% lower. The effect was influenced with the light level and was smaller (15% at 150 lux) at lower light levels. A more interesting effect was found in the differences between participants. A small group of 2 participants had markedly different answers and showed no effect of perceived whiteness on their judgment of brightness.

PS2-58

Smart Lighting Providing Different Optimal Visiual Illumination for Different Objects

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ABSTRACT

Unlike commonly mentioned smart lighting with the purpose of energy saving [1,2],the optimal visual smart lighting can provide different CCT conditions of lights for different objects to achieve

the best visual preference which is given as Preference=w1·lightness +w2·saturation [3]. This smart lighting contains two major parts, namely the color sensing unit and dynamic LED lighting unit. The dynamic LED lighting unit is composed of 4-channel LEDs can provide the light conditions of CCTs 2700K、3000K、3500K、4000K、4500K、5000K、5700K、6500K、9000K and 12000K.The corresponding color rendering indexes of these lighting conditions are greater than 85. The color sensing unit has RGB sensors to collect the raw data of the responded values of the R-, G-, B- sensors of the object illuminated by different CCT of lights, followed by a process of converting these R-, G-, B-values to the tristimulus values, X, Y, and Z of the object by a correcting matrix obtained from a training set of 20 pictures, and then to transfer the thistimulus values to saturation, lightness, and Chroma, thru a simplified formula which can be executed by 8051 microprocessor. Thus, the values of the preference of the object lighted by the ten light conditions are obtained according to saturation, lightness, and Chroma. The light with the largest preference value is the best one. An experiment is conducted by 20 subjects to evaluate the preference score ranged from 0 to 10 of a picture illuminated by different lighting condition. This subjective evaluation result is the same as the result obtained from the proposed LED smart lighting.

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PS2-59

Prediction of Acceptable Lightness Difference in Painting on Automobile Surface with Different Materials Based on Multi-angle Measurement

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ABSTRACT

It is difficult to judge whether variation in color occurring at a coat formation process is within an acceptable range. Even if we examine parts visually and their color appears fine, it would appear different when they are assembled into a car. Moreover, we often judge their color using color measurement apparatus, the measurement cannot necessarily reflect the color acceptance correctly. Since the measured color is only reference information, we always have to look at and check a car actually assembled. This is inefficient and cause many restrictions when we supply those parts from distant factories. It will be a great help to engineers in those factories if we can predict whether the color of parts is correct only by a measured color difference.

Paints for cars appear to be different color when a viewing angle changes. One of reasons why an inaccurate judgment for the color of paints is because the difference is judged only by a color measured with a fixed angle. Therefore, it would be effective to use a multi-angle measurement. I analyzed the color measurement data of vehicles made at a factory, and examined the relation between lightness L* and acceptable delta L* of the painted surface of metal-body and plastics-parts .

The range of acceptable delta L* changes with painted colors. Some paints shows larger acceptable delta L* range than others. When L* is high, the number of colors with large acceptance range of delta L* increases in general, but there are some exceptions. Lightness observed at five angles differ. They become higher if the measuring angle is close to a specular reflection angle, and vice versa. Not only L* of the brightest and the darkest angle differs, but the upward approximate curves of L* in a middle angle range differ.

The boundary of acceptance and unacceptance was compared to the combination of these features.
As a result, it is suggested that three features can explain the acceptance range of delta L* of five angles, and each angle's coefficient is calculated based on angle difference from specular reflection angle.

1) For a color with a big difference of L* between the brightest and the darkest angle, the acceptance range of delta L* becomes larger.

2) If L* from a middle angle goes up rapidly, the acceptance range of delta L* becomes larger.
3) If the L* of surface is higher in each angle, the acceptance range of delta L* becomes larger.
Color measurement apparatus usually obtain color difference based on data at a particular angle in spite of angle dependency in color. Misunderstanding would be caused if a color difference is calculated by CIELAB solely based on those data .Difference of delta L* near actual appearance may be predicted by correcting calculation using this method.

PS2-60

Visual Perception and Criteria for Good Lighting

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ABSTRACT

The study is conducted as a subproject in a dissertation titled Criteria for Good Lighting. The overall aim of the study is to, based on visual qualities - rather than physical measurements - research the possibility of creating lighting environments that inspires comfort and meets function while providing energy efficiency.

The study's specific objective is to formulate new criteria for a good light environment based on visual qualities, and to create a light simulator based on these criteria.

The background is that the lighting design today is most often based on photometry through lighting standards and norms. Photometry describes the eye's sensitivity to light in different frequencies of light radiation and how well it is possible to discern details in different amounts of light radiation. As a tool for lighting design the photometry and thus current standards are inadequate because it is mainly based on the detail vision's need of high light levels. But it is through the peripheral vision we understand the room, and it occurs primarily when the eye registers differences between contrasts in brightness and colour.

The idea that a good light environment primarily must meet high light levels in working and transportation areas has created the custom of illuminating horizontal planes as floor and table surfaces. This type of lighting design is inoperative if the purpose is to create a sense of space. The peripheral vision benefit more from illumination of vertical surfaces where a combination of light and colour makes the room legible.

A new definition of lighting criteria needs to be based on an understanding of how the visual perception functions; how to meet both the detail vision's need of higher light levels and the peripheral vision's need of a legible spatiality. Therefore, the criteria has to include a combination of parameters such as the light distribution, light levels and the properties and the colour of the reflective surfaces, and how they together create a good lighting environment suitable for human vision.

The study is conducted in two phases. The first phase is a pilot study where small groups of people is interviewed in their work environments in order to find out how they experience their work place and to what extent the lighting affects the experience. The pilot study does also include a literature overview on relevant research in the field of light, colour and visual perception. In the second phase, carried out with both quantitative and qualitative full-scale studies in an office environment where the subjects are tested in two types of room-settings. One corresponds to the lighting standards that are used today and the other has a light and colour design based on visual qualities and spatial perception, and the energy consumption will be measured in both room settings

PS2-61

Space Brightness Affected by a Scenic View through a Window

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ABSTRACT

There has been an increasing demand in the use of daylight through windows for maintaining bright visual environments while saving lighting energy. Recent studies have reported that although the horizontal illuminance – used as an index of human brightness perception in space – is increased by daylight, space brightness is not as efficiently increased as expected by the illuminance. In all of the prior researches investigating the window effect on space brightness, a room was equipped with a window of frosted glass. The main objective of the present study was to investigate the effects of a window with a scenic view on space brightness perception. The influences on space brightness were compared among different types of scenic view. In addition, we examined the effects of the appearance of an object placed by the window on the space brightness for an area by the window. In the experiment, the space brightness for two scale models simulating an office furnished with office fixtures such as desks and shelves was compared; one of them equipped with a window (a test room) and the other with no window (a reference room). Participants were asked to look into the two scale models, to compare them repeatedly, and to report numerically the brightness of the test room relative to that of the reference room using magnitude estimation (ME method). Two different types of scenic view were provided by inserting photographs of natural or urban landscape behind the window. Several levels of daylight intensity were simulated by changing the number of fluorescent lamps over the photograph. Each scale model was illuminated independently by a luminous ceiling with frosted grass and fluorescent lamps. A human-shaped foam core board covered with full-length photograph of adult male was set in front of the window to provide observers cues for the estimation of space brightness. The results revealed that although participants reported higher brightness with increasing intensity of daylight, the rate of increase was lower than that in the control condition where the test room was illuminated only by a ceiling light. Furthermore, the rate of brightness increase was lower compared to those obtained in the previous studies where a room of scale model was equipped with a window of frosted grass with no scenic view. When the human-shaped board was inserted at the window, the space brightness near the window decreased and the variance of ME reported by participants was smaller compared to the condition where no objects put at the window.

PS2-62

Influence of Surface Properties on Material Appearance

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ABSTRACT

Color Research has developed prosperously in these years, particularly on “color appearance”, which had made a significant breakthrough. Among them, textures, which is intimately related to color appearance, has got few attention. Features of textures possess enormous influences on surface color perception. Interactions between colors and surface materials have big stake on the accuracy of color display. Recently, the uprising of “material perception” researches have gradually filled up the insufficiency.

This research aims to explore the influences of material properties on the appearance of colors. By adopting the Cesia’s theoretical mode (Caivano, 1996), based on three elements of material properties: Permeability, Absorption, and Diffusivity, with the utilization of a rotary color mixer device, in adjustment with properties combined of various ratios of mirror surface, matted surface, and transparent surface, we investigate each element’s influences on objects’ surfaces’ color appearance and inspect influences of various texture on subject’s psychological feelings. The aim is to know how those influences perform? What are the influences formed on people’s mentality?

The purpose of the present research is to perform a quantitative survey on perceptions about material surface features in systematic ways, and to deliver results of practical data for subsequent researches on Cesia theory. The findings can provide advises on experimental operation, and broaden knowledge about influences of surface features on color appearance.

PS2-63

Visual Evaluation of a Wooden-finish Room and the Colorimetry of Wood

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ABSTRACT

It is known that there is a favorable effect psychologically and physiologically in which wood is used as building material or interior finish. There are many desirable aspects, for example, visual naturalness by wood grain tactile warmth, tactile smoothness, natural smell, and so on. Also the color and gloss of wood by aging are often liked, so wood has been used for a long time in many cases. Although these effects are acquired by natural wood, now the interior finishing paper that the wood grain is printed has also increased. In this case, can we expect the same effect of natural wood? We could expect it if only visual. It is supposed that visual effect depends on the surface color of wood, the difference of grain blend, and which color of the multicolored wood surface is observed.

The purpose of this paper was to clarify the difference in the visual evaluation of the wood color and the area of wood finish in a room.

Eleven kinds of wooden wallpaper samples in which colors differ were selected as interior finish of a room. A 1/20 scale model finished with the reduced photocopy of wooden wallpaper was made for subjective evaluation. The scale model was consisted of a living room, a dining room, and a kitchen. Subjects binocularly observed the scale model room through the observation window and evaluated by a semantic differential method. The area of wood finish in the rooms was changed in three conditions. The area of wood finish in the room was calculated from the indoor photograph taken from the subject's viewpoint. Therefore, the subjective evaluation was accomplished under the 33 conditions, the 11 colors and the 3 area proportions of wooden finish. The range of horizontal illuminance on the desk of the scale model was from 800 lx to 900 lx. Forty-five students of Mukogawa Women's University participated in the experiment. As a result of the subjective evaluation experiment, 2 factors were extracted, Harmony and Lightness. The area proportion of wooden finish and the color of wood have a great influence on both the Harmonious factor and the Lightness factor.

Further, the surface colors of the wallpaper samples were measured by a luminance and chromaticity uniformity analyzer (UA-10, Topcon). The relationship between the 2-dimensional colorimetric distribution of wood surface and the results of the subjective evaluation was examined.

PS2-64

Total Appearance of Metallic Coatings using a Stereo Capture System

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ABSTRACT

Over recent decades, the textured coating provided by metallic surfaces has been an important factor in attracting customers of the automobile industry. This has meant that quantifying the appearance of coating products is essential for product development and quality control. The appearance of these coated products strongly depends on the viewing geometry, giving rise to a variety of properties of perceptual attributes such as texture, colour and gloss. Due to the visually-complex nature of such coatings, there remains an unsatisfied demand to develop techniques to measure the total appearance of metallic coatings.

This paper describes a study which aims to define the total appearance of metallic coatings and then objectively characterise it. Total appearance here refers to the combination of three properties of perceptual attributes of the surface: glint, coarseness and brightness. A number of metallic panels were visually scaled and a computational model capable for predicting three perceptual attributes was developed. Ten observers with normal (or corrected to normal) visual acuity and colour vision participated in the assessments. They judged three perceptual attributes of 54 metallic panels under

directional illumination by comparison with a reference sample. The session was carried out twice, each on a different day, in order to test repeatability. Each session lasted around 35 minutes, but was limited to 45 minutes so as to avoid visual fatigue.

A computational model was developed to relate the results from this psychophysical experiment to data obtained from a stereo image capture system. This is a new alternative technique aimed at solving one of the most challenging problems in computer vision: stereo matching. In the system, two images are captured by a same camera under two different lighting conditions to mimic stereoscopic vision. This not only addresses the problem of stereo matching (i.e. to find the corresponding pixels between two images) but also enhances the effect of perceptual attributes, especially glint. An HDR image system was employed to obtain the full dynamic range of a scene in a single image. After linearisation of camera response, spatial uniformity correction was performed to minimise the effect of uneven illumination. A characterisation method was then used to transfer the HDR data to device-independent values. Two images captured under different lighting conditions were merged to obtain stereo data. The pixels in the final image were segmented into two regions: bright spots and dark background. Next, statistical analyses were applied to extract features. Finally a model was created to predict the perceptual attributes of the metallic coating panels based on an image captured by the stereo capture system.

PS2-65

Statistical Image Analysis for Evaluating Face Shine: Cosmetic Research

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ABSTRACT

Cosmetics, particularly base-makeup items such as foundation, are expected to provide beautiful shine with faces. In the process of cosmetics development, therefore, it is critical to understand factors that affect features of face shine. For exploring such factors, we propose a novel statistical facial image analysis method for characterizing features of face shine from the spatial distribution of brightness (texture) appearing on facial images. We first constructed an original facial image database as learning data for statistical analysis (the database is composed of 420 Japanese female faces with and without base-makeup). Since our aim is to evaluate the features of face shine from the standpoint of facial "texture" (not facial "shape"), we have to normalize the facial shape in order to remove the variations of facial shapes. To this end, we normalized (unified) each facial shape in the database to a mean shape of samples by using a warping technique. These shape-normalized facial images are used as samples for statistical texture analysis. We used principal component analysis (PCA) to calculate eigen modes of the facial texture. Each mode represents a specific feature of the texture. The facial image with different texture can be reconstructed by the use of different modes. In the proposed method, we first reconstructed facial images that had different cumulative contribution rates (ACR). Information regarding the differences between the reconstructed facial images was then used to extract textures that determine the features of face shine. Facial images with different face shine are used as test images for analysis. The results showed that feature of facial shine was expressed by two factors: the first one was texture derived from ACR about 64 % ~ 97 % (eigen modes from middle- to high-order); and the second derived from ACR about 82% ~ 97 % (eigen modes of high-order). Additionally, from the subjective evaluation, we found that texture that appeared in higher-order eigen modes tended to give worse impression to face shine. Residual images between the original faces and reconstructed faces without texture of ACR 82% ~ 97 % expressed facial local non-uniformity such as facial pores. This result clearly showed that facial local non-uniformity would deteriorate face shine. This result provides us with important indication for the design of base-makeup items: in order to develop the items that achieve beautiful face shine, it is critical to restrict facial skin local non-uniformity effectively with keeping face shine.

PS2-66

High Dynamic, Spectral and Polarized Natural Light Environment Acquisition

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ABSTRACT

In the field of the image synthesis, the simulation of the material's appearance requires the rigorous resolution of the light transport equation. This implies to take into account all the elements that may have an influence on the spectral radiance, and that are perceived by the human eye. Obviously, the reflectance properties of the materials have a major impact in the calculations, but other significant properties of light such as the spectral distribution and the polarization must be taken into account, in order to expect correct results. The image rendering under natural light is very dependent of a rigorous characterization of the source, unfortunately real maps of the polarized or spectral environment corresponding to a real sky do not exist, except only for a few simplistic parametric models. Therefore, it seemed necessary to focus our work on capturing such data, in order to have a system to quantify all the properties and capable of powering our future simulations in a renderer.

In this work, we develop and we characterize a device designed to capture the entire light environment, by taking into account both the dynamic range of the spectral distribution and the polarization states, in a measurement time of less than two minutes. Sky light is collected by a fisheye lens through a series of polarizing and bandpass filters mounted on two motorized wheels. Each sequence of (6 x 17 = 102) images is recorded by a "Wide Dynamic Range" CMOS sensor. Thereafter, the images are processed and transcribed in a data format, inspired by polarimetric imaging and fitted for a spectral rendering engine, which exploits the "Stokes-Mueller formalism."

We are assuming that the proper consideration of this new information will improve:
- The accuracy of color and aspect reproduction.
- Efficiency of the simulation for several specific effects (such as absorption, dispersion, diffraction, interference, ...).
- Anticipate the metamerism phenomena.

PS2-67

Development of Skin Reflectance Prediction Model Using Skin Data

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ABSTRACT

Interest in the spectral reflectance of human skin has been greatly stimulated by the increased need for a fundamental understanding of human skin appearance, including skin colour reproduction for graphic arts, skin pigmentation prediction for the cosmetic industry, skin colour measurement for the diagnosis of cutaneous disease, skin colour matching for body and maxillofacial soft tissue prostheses. In comparison to CIE colorimetry, skin spectral reflectance data are more informative since they provide information about skin colour independent of the prevailing illumination and can be directly linked to skin chromophores.

Previous studies have found that three basis functions obtained by Principal Component Analysis (PCA) are sufficiently accurate to describe the spectral reflectance of human skin and therefore the spectral reflectance can be estimated for each pixel of RGB facial image. However, human skin is a non-flat multi-layer material with non-uniform colour properties. When a conventional method for camera colour profiling using a standard colour chart is applied to make skin colour predictions, the predictive error is large. This may be caused by the material difference (between the skin colour chart

and human skin) and the uniformity problem (in both the colour chart and the subject's face).

The aim of this study is to develop a new skin reflectance re-construction model which will enable us to predict skin reflectance from a RGB facial camera image. Images of human faces from 100 subjects each for a Chinese and Caucasian ethnic group were captured using a Nikon camera system under controlled viewing conditions and spectral reflectance functions of the skin were obtained in four facial areas using a Konica Minolta CM 700d spectrophotometer. Rather than using a standard colour chart, a reflectance re-construction model was developed using skin colours of a subset of the subjects and evaluated using the remaining set. We will focus on how the training colours are to be selected and the precise mathematical model. Model performances using real skin colours as well as the standard colour charts will be discussed.

PS2-68

Comparing CSI and PCA in Amalgamation with JPEG for Spectral Image Compression

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ABSTRACT

Continuing our previous research on color image compression, we move towards multi-spectral image compression. Multi-spectral Images can be extended beyond the visible range of electromagnetic spectrum and each pixel spectra is normally sampled and stored at 10nm, 5nm or 1 nm intervals. So this enormous amount of data needs more space to store and more time to transmit. To manage this sheer amount of data, researchers have employed and investigated different data compression techniques so that image quality can be conserved and compressibility can be improved. While developing a compression algorithm, information loss and processing complexity should also be considered along with the compressibility. The principle component analysis (PCA) combined with JPEG has been employed to reduce the dimensions of spectral images to achieve high compressibility and performance. In the current work, keeping in mind the processing complexity of PCA, a simple interpolation technique called cubic spline interpolation (CSI) was used in amalgamation with loss less JPEG2000 to reduce the dimensionality in the spectral domain of multi-spectral images. The CSI is preferred over other polynomial interpolation techniques because of its robustness against so called Runge's phenomenon and especially smoothness at the edges which is very important while doing image calculations. Initially, four hyper-spectral images were taken as test images. The CSI and PCA were employed one by one in the spectral domain and lossless JPEG in spatial domain. The performance results of both algorithms were then compared in terms of compressibility, processing complexity and acceptability. Three measures including compression rate (CR), processing time (Tp) and CIEDE2000 color difference formula were used for performance analysis. The CIEDE2000 is CIE color difference formula, best correlated with the human visual perception. Test results showed that for a fixed value of compression rate, CSI based algorithm gave acceptable performed in terms of dE00 but was found less complex and computationally much cheaper comparing with PCA. Results showed that processing time of PCA based algorithm increases linearly but that for CSI it remain almost constant after certain increase in size of image. Computational efficiency becomes even more important when large size spectral images need to be compressed that may take several minutes to process even on a powerful computer. With the increase of image size, complexity of PCA increases rapidly and hence takes more time to process. We observed that for an image of above 200x200 pixel size (which is normal), a computer system with 32GB primary memory have gone out of memory in the PCA based algorithm while this did not happen for CSI based algorithm. We are also conducting psycho-physical experiments by including more number of images and statistical results will be reported in the full paper.

A System for Analyzing Color Information with the Multi-spectral Image and its Application

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ABSTRACT

With the development of multi-spectral cameras, it has become easier to take a multi-spectral image of ordinary scene. This means that the information from a multi-spectral camera would be a strong tool to obtain and analyze the color information of various environments. However, it is complicated to extract color information from raw spectral distribution data in a multi-spectral image since a precise color calibration and the calculations of colorimetric values such as chromaticity coordinates are required.

We have constructed a system which can analyze color data from spectral data taken by a multi-spectral camera. First, ununiform intensities and the shape of spectral distributions in an image due to the sensitivity of each sensor in a camera were calibrated based on a uniform reference light through integrating sphere. Then the CIE1931 XYZ were calculated using the obtained precise spectral distributions and the color-matching function. It is also possible to transfer to the other chromaticity values such as the CIELAB and LMS cone responses. With this system, we can analyze color statistics (e.g. average color and color distribution) of an image, and also can convert the multi-spectral image to a RGB image

As an example of application, we compared those color information and spectral distribution to analyze and simulate the color appearance of normal color vision, dichromat and anomalous trichromat. We took multi-spectral images of traffic signals with new LED and old type lamps. The CIE1931 xy chromaticity coordinates of red, green and yellow traffic lamps were calculated from the multi-spectral images. We also simulated the different degrees of color deficiency by shifting L or M cone spectral sensitivity based on a model proposed by Yaguchi et al. (ICVS2013) and reproduced the simulated RGB images of color deficiencies. We examined simulated chromaticity coordinates of old and new traffic signals. The results show that the simulated chromaticity coordinates of dichromat and anomalous trichromat are different from normal color vision for both old and new traffic signal in the case of red and blue signals. In the case of yellow, however, the simulated chromaticity coordinates of dichromat and anomalous trichromat is very different from normal color vision for the new traffic signal, while there is no difference for the old one. With those simulated images it is easy to see the difference of the normal color vision and color deficiencies. This type of analysis with this system would be important for color vision research and color universal design. It is suggested that our system contributes to study and analyze various environments using multi-spectral images and their data.

Abstracts

MCS Poster Papers

PS2-70

Quality Comparison of Multispectral Imaging Systems Based on Real Experimental Data

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ABSTRACT

Multispectral imaging (MSI) acquires images in a limited number of relatively wide spectral bands, and the spectral reflectances are obtained from the sensor responses using a spectral estimation method. MSI provides a simpler, faster, and cheaper solution to spectral imaging compared to hyperspectral imaging. Even though a number of multispectral imaging systems have been proposed in the literature before, the existing state of the art multispectral imaging systems are still mostly slow, complex, and expensive for their wider acceptance and use. We proposed two fast, practical, and cheaper multispectral systems: single shot 6-band stereo camera (StereoMSI)[1], and RGB camera based LED illumination based (RGB-LEDMSI) systems[2]. In this paper, we evaluate and compare the quality of these systems along with a conventional filter wheel based MSI system (FWMSI) through experimental measurements from the prototype systems, and provide evaluation and comparison framework along with detail analysis and discussion on the results.

We developed three prototype systems: one StereoMSI, one 6-band RGB-LEDMSI, and one 9-band RGB-LEDMSI. The StereoMSI system is built with a Fujifilm FinePix REAL 3D W1 stereo camera, and a pair of optimal filter selected from a set of filters placed in front of the two lenses of the camera. The 6-band RGB-LEDMSI system is constructed with a Nikon D600 RGB camera, and the six LEDs from JUST Normlicht's LED ColorControl light booth. This is considered as a constrained LEDMSI case where the number of LEDs is limited to six. The 9-band RGB-LEDMSI system is constructed also with a Nikon D600 camera, but using nine optimal LEDs selected from the 22 LEDs in an iQ-LED module from Image Engineering. We use a SpectroCam FWMSI system from PixelTeQ, with six filters in its filter wheel.

The four systems are evaluated and compared based on the spectral as well as colorimetric accuracies of the spectral reflectance images produced by the systems. The mean metric values are commonly used to compare different systems. In this paper, we also propose a cumulative distribution function (CDF) based measure for more effective and consistent comparison of the systems. We think that the quality comparison framework and the methodology provided in this paper would be useful in identifying the most appropriate technique or system for a given application.

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PS2-71

LED-based Gonio-hyperspectral System for the Analysis of Automotive Paintings

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ABSTRACT

Concerning to the variability of the visual appearance as a function of the illumination and observation direction, several industries have designed coatings that reproduce and exploit the potential of this effect. Two clear examples are the cosmetics and automotive industries, being the latter the one chosen as the target of this work. Materials that contain goniochromatic pigments are divided in two

categories: metallic and pearlescent. Regarding the metallic pigments, they mainly exhibit variations in lightness for different angular positions, while the pearlescent pigments present changes in hue and chroma. In order to evaluate these colorimetric features, commercial multi-angle or gonio-spectrometers have been recently developed such as the BYK-mac®, the X-Rite MA98® and the Datacolor FX10®. With the same purpose, spectral imaging systems can also be very useful. Nevertheless, available gonio-spectral imaging systems are linked to restricted spectral ranges and resolutions, besides being primarily used only under specific research premises. Therefore, with the aim of overcoming these limitations, a novel gonio-hyperspectral system based on LEDs is presented here. The proposed device is composed by two motorized rotation stages, two cameras and a LED-based light source. One of the rotation stages controls the angle of illumination by rotating the sample with respect to the light source while the other one controls the observation angle by moving the arm that supports the cameras. The imaging set includes a visible CCD camera with enhanced sensitivity in the ultraviolet region of the spectrum (1392x1040 pixels) and an InGaAs camera covering the near-infrared range (320x256 pixels). The light source is constituted by 29 different kinds of LEDs from 365nm to 1300nm that are mainly concentrated in the visible range. White LEDs were also incorporated to analyse the sparkle, graininess and mottling of surfaces, which are descriptors of the texture of samples also used in the automotive industry to describe appearance of coatings besides colour appearance. In addition, a linear actuator holds the LED board and allows changing from one spectral channel to the next one. The gonio-hyperspectral system had a field of view of 5.3x3.9cm. As a first approach, the geometries shared by the BYK-mac®, the X-Rite MA98® and the Datacolor FX10® were evaluated (45ºx:-60º, 45ºx:-30º, 45ºx:-20º, 45ºx:0º, 45ºx:30º and 45ºx:65º) to compare their results with the ones obtained by the proposed system. The sampling set consisted of 30 samples of real automotive paintings: 10 solid, 10 metallic and 10 pearlescent. The colorimetric analysis of the samples as well as the comparison between instruments were performed in the CIEL*a*b* colour space. The L*, a* and b* values were similar among them, including the results from the system developed in this study. However, the development of indexes for the quantification of sparkle, graininess and mottling will be studied in future work. The results of this study show the usefulness of the developed system in the assessment of colorimetric features of coatings containing goniochromatic pigments but with a high spatial resolution, overcoming some of the inherent limitations that currently existing instruments for their characterization have.

PS2-72

Multispectral Image Estimation from RGB Image Based on Digital Watermarking

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ABSTRACT

The multispectral image which enables more faithful color reproduction than RGB image is expected to be applied in a wide range of fields including digital archiving and medical imaging. However, it is necessary to convert the multispectral image into the RGB image so far because the infrastructure for using the multispectral image is in development. Some conventional studies have proposed the estimation method of the multispectral image from RGB image, but the improvement of the estimation accuracy is always an issue.

In this paper, we propose a method of embedding the spectral information in an RGB image by the digital watermarking. The proposed method divides the multispectral image into two components before embedding: RGB image and residual. The RGB image is extracted from the multispectral image by using the XYZ color matching functions, a color conversion matrix, and a gamma curve. The original multispectral image is estimated from the RGB image by Wiener estimation, and the difference between the original and the estimated multispectral image is referred to as the residual. In our method, the estimated spectral residual data are compressed by JPEG2000 and embedded in the lower bit planes of the RGB image. The proposed method can adjust the quality of the recovered multispectral image by changing the amount of the embedded residual data.

The experimental results show that the proposed method leads to more than 10 dB gain relative

to conventional methods in the peak signal-to-noise ratio comparison of recovered multispectral image. This is because the conventional methods cannot use any spectral information when estimating the multispectral image. Although the proposed method degrades the RGB image quality, the experimental results show that the RGB quality of the proposed method is more than 35 dB and there are almost no significant perceptual differences from the original RGB image. The experimental results show that the proposed method can improve the quality of the recovered multispectral image at the expense of a slight degradation in RGB image quality.

PS2-73

Image Correction for a Multispectral Imaging System Using Interference Filters and Its Application

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ABSTRACT

A multispectral imaging system can improve color accuracy in the captured images, compared with a general RGB camera system. Also the system makes it possible to estimate important surface properties such as spectral reflectance at each pixel point of an object surface. Therefore, a variety of multispectral camera/imaging systems have been proposed for the purpose of estimating spectral information such as spectral radiance in a scene and surface-spectral reflectance of an object.

The authors so far have developed multispectral imaging systems for image acquisition for the purpose of digital archiving of art paintings. The systems were mostly based on use of color filters with wide wavelength bands. It should be noted that narrowband filtration is desired to recover the details of surface-spectral reflectance.

The present paper proposes an improved multispectral imaging system using interference filters with the property of narrowband filtration for the purpose of estimating the detailed spectral reflectance shape of an object surface. The imaging system is composed of a monochrome CCD camera, a C mount lens, an automatic filter changer, and eight interference filters. It should be noted that the focus position and focal length are changed in image acquisition because the interference filters have different indices of refraction. This effect is a type of chromatic aberration. When combining the captured spectral images by the eight interference filters, this effect causes the registration error of images

In this paper, we develop an algorithm for correcting the registration error. The method is based on the phase analysis of images in Fourier domain. We use the phase-only correction (POC) method for correcting the registration error. The POC method is a technique for calculating the correlation by using a phase image. A phase image is an image that the amplitude spectrum of the image is normalized by 1. The pixel value in multiband image is obviously different in each band images even if it takes a picture of the same scene. Therefore, it is difficult to correct a registration error between images using a general correlation technique. By contrast, in the proposed method, it is possible to calculate a correlation without influence of a variation in the amplitude spectrum, and it can be expected to improve the accuracy of the corresponding point detection. For this correction, one of eight images is selected as a reference image and the remaining seven images are corrected as target images. Because the registration error is not always common on the image plane, we divide the image plane into small regions and perform correction for the respective regions.

Next the correction method is applied to digital archiving of oil paintings based on the present imaging system. The realistic images of the painting are rendered under arbitrary conditions of viewing and illumination. We evaluate the estimation accuracy of the surface spectral reflectance and surface shape from the correction images. The feasibility of the proposed method is shown on experiments using real painting objects.

PS2-74

Development of Multi-bands 3D Projector

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ABSTRACT

Recently, we can enjoy three dimensional images at standard home for a reason that a three dimensional display becomes less expensive. On the other hand it is necessary to represent an image with exact color information and high resolution in various fields. However reproduction of exact color is difficult because of the three RGB primary colors and insufficient color gamut. There are some researches of a display system with multi-primary colors that can display spectral images with high dimensional spectral information in each pixel, but most of the existing display systems become expensive because the systems have complex mechanism. Also there are fewer researches that deal with the color reproduction and three dimensional image at the same time. Therefore if it is possible to construct a simple system using general 3D projectors and filters, it is considered that the three dimensional image with exact color can be displayed.

This paper aims to develop a three dimensional display system that can project three dimensional images with wide color gamut. Concretely speaking, we propose a method for expanding the color gamut of a three dimensional image by carrying out projection of the multi-primary color more than RGB 3 bands using two 3D projectors with different spectral characteristics. First, the most suitable spectral transparent characteristics of band cut filters are determined by means of computer simulation. And the band cut filters with the determined spectral transparent characteristics are made experimentally. These filters enable to change the spectral characteristics of the projectors according to attached in front of the each projector.

To show effectiveness of our proposed system, a prototype display system is constructed, and the color gamut of the system is measured. Moreover we will try to display spectral video and spectral three dimensional images with the use of the system, then we will evaluate abilities of the our prototype system.

PS2-75

Perceived Quality of Printed Images on Fluorescing Substrates under Various Illuminations

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ABSTRACT

In printing, colorimetric workflows ensure that the print looks as good as possible under one specific illuminant (typically daylight), but without accounting for the fact that colors, and therefore color differences, may change drastically from one illuminant to another [1]. This effect is referred to as metamerism: two objects may seem to have the same color under one light, but not under another. There are several applications which require to have some control over the quality of a print under various viewing conditions, and for which colorimetric workflows are thus not appropriate. Furniture catalogues or paint swatch books are among these applications as it is important that customers have a good idea of the color of a piece of furniture or a particular pigment under the light of e.g. their living room. Only in a spectral workflow is one able to have such control, by using the pixels' spectral reflectance factor, rather than e.g. RGB or CIELAB values. Controlling quality in such workflows is however challenging due to the potentially large number of viewing conditions that need to be considered (e.g. all kinds of domestic lights) and because distances between pixels (e.g. the Euclidean distance) carry very little meaning in terms of perception, when computed in the "reflectance domain" (as opposed to the "color domain").

There are a variety of so-called image-difference metrics in the literature, that aim at predicting the perceived difference between an original image and a reproduction (e.g. a simulated print), using features such as structure, contrast, detail visibility, etc… However, most of these metrics work with three-dimensional color spaces optimized for one illuminant only. Recently, a scheme was proposed to extend one of these metrics, called CID, for spectral workflows by simply using a set of representative

illuminants and averaging the results of the CID under each of them. The resulting metric is referred to as the Spectral Image Difference (SID) metric [1] and it has been reported to significantly outperform traditional spectral difference metrics such as the root-mean square error (RMSE) when compared to subjective data.

Although SID can be applied to control quality within a spectral printing workflow, it fails to consider paper fluorescence and its impact on the perceived quality of the print. It is well known however that optical brighteners are used to make papers look/appear whiter. These dyes absorb UV radiation and re-emit light in the blue region of the electromagnetic spectrum. In this study, we investigate the influence of paper fluorescence on perceived image quality. Given a variety of multispectral images, we simulate the output of a CMYKRGB printer by means of a spectral gamut mapping [2]. We then demonstrate that adding a model of paper fluorescence and ink UV absorption leads to substantial changes in the SID scores and thus in the perceived quality of the print, even when also simulating chromatic adaptation [3]. These findings are of particular interest for soft- and hard-proofing applications in spectral printing workflows.

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PS2-76

To Predict Reality in Virtual Environments: Exploring the reliability of colour and light appearance in 3D-models

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ABSTRACT

To predict how the not yet built environment is going to appear regarding light and colour is a crucial problem for architects and designers. 3D-visualization is an established design tool and used for representations of project proposals. In many cases, the aim with the visualizations is to make good-looking images sell the design. In order for software, such as 3Dsmax to become a usable planning tool of light and colour in buildings, the visualization must be trusted to show the correct appearance in accordance with the physical preconditions of reality. The complex interaction between light and objects makes the problem of lighting scenes central within computer graphics. In a previous study (2006, 2005, 2004), various problems related to the rendering of light and colour in interactive models made in 3Dsmax. Since then, the technology within colour rendering and computer graphics has moved forward. This paper discusses the problems of translating reality to its digital counterpart. New tests were performed in 3Dsmax in order to explore the usability of various rendering techniques and to explore the trustworthiness of colour and light representations. We deal with methodological issues concerning how to compare visual results between different media, mixed adaptation and arbitrary parameter setting in the software.

In the earlier studies carried out 10 years ago, a 25 m^2 real room was compared to different Virtual Reality (VR) simulations. In order to get a simulation as correct as possible of the 6 fluorescent luminaires (2 ceiling armatures and 4 wall washers) the manufacturer Fagerhult's own IES-files were used. At that time, this photometric light could only be rendered with the default Scanline renderer in 3Dsmax, which resulted in significant differences between the real and the virtual rooms. The VR-models had incorrect reflection effects between surfaces, too few colour variations and too achromatic shadows. Also they had incorrectly reproduced contrast effects for the lightest surfaces. The surface that was perceived as the whitest in the room appeared too grey.

In our new study, the original models in 3Dsmax Design 2014 were rendered with the Scanline renderer, Mental Ray and V-ray. The light planning software Dialux was used for comparison regarding the light level and distribution.

Preliminary results show improvement regarding interreflections and colour variations.

However, there are still incorrectly reproduced contrast effects and the whitest areas appear too grey. The light level also differed compared to the situation in Dialux, even if the same light fixtures and IES-files where applied. Furthermore, we will discuss issues concerning the choice of correct parameters to represent the physical prerequisites of reality, such as the problem of deciding how many times a light should bounce. One dilemma is that the architects and designers have knowledge of colour and light in reality, however do not usually know how to use all features in the software. The professional visualizers know how to manipulate 3D-models to look good, but often do not regard physical correctness.

PS2-77

Altering Perceived Depth of Objects with Colored Lighting

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ABSTRACT

In this study, we have specifically explored effect of lighting (especially colored lighting) to see how it would affect chromostereopsis, a phenomenon in which colored objects located on the same plane are perceived to be on different planes. Studies have found that red was more often perceived to be closer than blue, even when they are on the same plane. However, Vos (1960) discovered some people experience the reverse effect or even no effect. Itten (1973) attributes this spatial effect of color to be based upon an object's context color or surround. Just as an object color is influenced by its context, color appearance can also be influenced by the quality or color of light in the scene. However, academic research on chromostereopsis or real-world applications of color's spatial effects make very little, or even no, mention of the effect of lighting on the phenomenon. Some discount the lighting or illuminants in their experiments due to the negligible difference that lighting makes in their topic of research.

To test the effect of colored lighting on chromostereopsis, a psychophysical experiment was conducted, using tone-mapped, HDR pictorial images of a scaled model as stimuli. The scaled model of an enclosed, uniformly-colored gallery was illuminated by skylights, and contains two differently-colored objects (one red and one blue) that seemingly float in space. The skylight over the end of the gallery would have colored "filters" to simulate the seven test conditions were developed for the experiment—neutral (or uncolored), and two variations each of red, blue, and yellow lighting. The stimuli were then presented at a random sequence to subjects, who were asked to report which of the two objects appeared nearer based on the object's color appearance.

Preliminary findings indicate that under colored lighting, the perceived depth of objects vary depending on the contrast between an object and its context. Under the various lighting colors, the color appearance of the red and blue objects did not change very much, as compared to the rear wall of the gallery (which became the context color for the objects). Under neutral and blue lighting, the red object was perceived to be nearer, but under red and yellow lighting, it was the blue object that was perceived to be nearer.

PS2-78

A Model for Estimation of Overprinted Colors on *Nishiki-e* Printings

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ABSTRACT

Nishiki-e is a type of *Ukiyo-e*, Japanese historical art and multicolored woodblock printings. A *Nishiki-e* printing was produced by a set of printing blocks. Today, some sets of printing blocks still remain, but some of printed image were lost over the year. Reproduction of lost *Nishiki-e* printings is desirable. But it is impossible that colorants are immediately put on a printing block for reprinting because these have great historical value and should not be damaged.

Now we are trying to establish a digital reproduction method of *Nishiki-e* printings based on the measurement of shapes of printing blocks and multispectral information of colorants. In our previous work, the measurement of printing blocks using a photometric stereo method was successfully executed[1]. This paper focuses on color information and proposes a model of estimating color of overprinted colorants.

Accurate color information is essential in order to reproduce *Nishiki-e* more realistically. *Nishiki-e* has two way of representing color. One way is to put only single colorant on paper, and the other is to put more than two colorants on paper one by one. The color information of single colorant part is available by measuring another *Nishiki-e* where the same colorant is used. However, in regards to overprinted color, it is difficult to get the color information because the information of overprinted part by specific pair of colorants is not necessarily obtained from another *Nishiki-e*. Then, a model of estimating color information of overprinted colorants using color information of single colorant is required.

The color of overprinted colorants is changed by the order in which colorants overlap. Assuming that color overprinted part has a kind of layered structure, we construct a color estimation model which consider the order using Kubelka-Munk theory. Furthermore, spectral reflectance obtained by measuring single colorant part of *Nishiki-e* is applied proposed model in order to estimate the overprinted color. Then, the estimated result is compared with a measured value of overprinted part to confirm the validity of the model. Some *Nishiki-e* printings which are owned by the National Museum of Japanese History, Chiba, JAPAN are measured. From measured values of real *Nishiki-e*, it is observed that transparency of upper layer colorant is higher than estimated values. Improvement of the model is our future work.

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PS2-79

Ethical Considerations on Gene Therapy for Color- Deficient People

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ABSTRACT

In 2009, a procedure based on somatic gene therapy for creating trichromacy in dichromatic monkeys has been proposed by Mancuso et al. Although this procedure might also be used to "treat" color deficiency in human observers, the method has not been adapted for humans and/or permitted for human trials yet. On the one hand, ethical concerns can be raised that are closely related to the general discussion about somatic gene therapy. On the other hand, there are great prospects in the proposed method related to not only creating trichromacy in dichromats, but possibly even tetrachromacy in trichromats.

We argue that tests that would adjust the proposed method for humans and clinical trials should be allowed, as long as the tests and trials fulfill internationally approved requirements like for example that the technique has been tested sufficiently on animals, that the risks are minimized for humans, and given that clinical trials follow international standards like for example the informed consent etc.

One main factor in the ethical debate about gene therapy for color deficient people is whether this type of gene therapy would be defined either as somatic gene therapy to correct a genetic defect or as enhancement genetic engineering. In other words, whether color deficiency is defined as disability or as non-harmful anomaly.

We argue however that color deficiency does not qualify as "real" disability, and thus main costs for research and treatment should be carried by private actors and the patients themselves. This also means that only somatic gene therapy should be allowed and not germ line gene therapy for color deficiency. Distress of color deficient people mainly arise in social settings, where communication is heavily based on color coding like for geographical or public transportation maps, in advertisement, ob websites etc. From a social view point, other image improvement methods like daltonization should therefore be prioritized for public funding, and general implementations of usability resulting in better navigation and communication for not only color deficient people but other groups of people that have aspects of vision that differ form the majority of people like the elderly and others.

PS2-80

Robust Cross-Domain Reflectance Estimation

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ABSTRACT

A common step in multi-spectral imaging is the estimation of spectral reflectances from camera responses. Most practical spectral reconstruction methods rely on examples to learn a transformation from camera responses to reflectances.

The main problem then lies in the selection of training samples. It is often impractical to produce the required number of samples for a given algorithm and application.

Instead, samples from a different "domain" are used: a standard color chart, e.g. a ColorChecker, as well as printed or painted samples, depending on the application. The word "domain" refers to any systematic differences influencing the measurement results. Different paper types, printing inks, measurement conditions or gloss levels could all be seen as separate domains. This leads to problems if the estimation algorithm tends to overfit the training data.

One example is print inspection: we want to estimate the reflectance spectra of colors in an offset printing machine, but for training only standard color charts or samples printed on a different printer and paper are available.

We examine a number of spectral estimation methods in the context of cross-domain calibration using real-world camera data from multispectral imaging systems (data will be available online). Results show that a robust linear least squares algorithm often outperforms more complex methods when training and test data are from different domains.

PS2-81

Colorama: Extra Color Sensation for the Color-Deficient with Gene Therapy and Modal Augmentation

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ABSTRACT

Discomfort and problems for color deficient people in daily life are closely connected to social settings, i.e. settings where our society heavily relies on color coding as tool of communication as can be seen in geographic or public transportation maps, advertising, etc. In image processing, so-called daltonization methods have been developed to help color deficient people. However, these methods do only help to differentiate otherwise confusing colors. They do not, however, create the sensation of missing color hues in color deficient people.

Fortunately, there has been made significant progress in the field of sensory substitution in the past years and decades. Sensory substitution describes devices that translate visual information into other senses especially for the blind. In this paper, we are going to review up-to-date methods in sensory substitution, especially in the form of sound-for-vision and touch-for-vision methods, and outline how these methods can be used in order to enable color deficient people to perceive as wide a range of different color as normal sighted people can. We argue that those devices can be divided into two main groups: Firstly, those that can directly be attached to the body of a person resulting into synesthetic sensations as some researchers suggest, and secondly, those that have to be handled manually, which are more easily implementable in today's mobile and tablet devices.

Moreover, a genetic therapy method has been proposed to create trichromatic vision in color deficient people by Mancuso et al. in 2009. We discuss how this method can be used to make color deficient people into trichromats, and we discuss how this method can be used to make trichromats into tetrachromats enabling them to see even more colors and hues than before.

Finally, even though both methods would lead to a improvement for color deficient people, problems related to feasibility and costs remain. We argue that both methods mark a more or less intrusive intervention through medial treatment or additional devices that have to be carried around., and that the medical treatment and devices mean relatively high costs. However, progress has been made especially in the field of mobile devices and smart watches that could also be used for sensory substi-

tution for color deficiency. We point out that although both gene therapy and sensory substitution mark an important advancement for color deficient people, it is still important to focus on universal design and the improvement of usability in today's media outlet.

PS2-82

Benchmarking a Grating-Based Spectral Imaging System

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ABSTRACT

Spectral imaging system handles image signals in spectral form. Different approach can be used to generate spectral image. One early spectral camera system uses tunable liquid crystal tunable filter for capturing 31 channels of narrow band signals respectively. On the other hand, multi-filter camera system uses optimized filters with monochromatic camera to captures spectral data and then to numerically process the data into finer spectral resolution. Another example is two-filter RGB camera system that captures image with RGB CCD sensor array through specifically optimized filter pair. Numerical process is followed to expand the data into finer spectral resolution (like 10 nm). Each method deploys different hardware device resulting in unique pros and cons.

A newly developed gating-based device (spectrograph) is deployed in this research to make a spectral imaging system for digital archive of small museum objects. The image is captured in line-by-line manner. The incoming light of very pixel on the line is dispersed by the spectrograph into a series of spectrum to be projected on a monochromatic CCD sensor array perpendicular to the line direction. The two-dimensional signals on the CCD sensor array will be the spectral data on every pixel of the scan line. The spectrograph, lens, CCD sensor array, and illuminants are mounted on a two-dimensional scan bed to capture image in strip for all visible wavelengths in single pass. This can avoid the potential registration problem from multiple exposures due to the move in changing filters. After calibration to a known reference standard and post-process the spectral reflectance factor for every pixel in visible region in 10 nm resolution can be produced.

The focus of this study is to benchmark this gating-based spectral imaging system. Its colorimetric performance and other properties will be investigated. The results will provide a good reference to the spectral imaging research.

PS2-83

Experimental Evaluation of Chromostereopsis with Varying Spectral Power Distribution of Same Color

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ABSTRACT

We experimentally show that spectral power distribution (SPD) of a displayed color effects on depth perception. Even when SPD of a color consists of a summation of several SPDs with a single peak, the same chromaticity value can be obtained from the color whose SPD has a single peak. Under assumption of chromostereopsis being explained by the model based on the transverse chromatic aberration, SPD of displayed color effects on the impression of depth. Then, we assume that an observer perceives a color whose SPD has a single peak and its full width at half maximum (FWHM) is small to be placed in front of the same color whose SPD consists of a summation of several SPDs with a single peak.

For verification of this assumption, experiments described below were conducted. Our experimental system consists of a liquid crystal display (LCD) panel with a red-green-blue filter array, two xenon lamp systems, a metal halide lamp and band-pass filters. The xenon lamp systems and the metal halide lamp are used for backlight of LCD. A band-pass filter is attached in front of a lens of light-guide optical fiber of metal halide lamp. Light from the metal halide lamp are used as a target color. The xenon lamp system consists of xenon lamp, ND filter and a filter turret on which eight filters

can be attached. Brightness and filter turret can be controlled by software on PC. Light from two xenon lamp systems are combined by light-guide optical fiber. The combination of band-pass filters and brightness of light are changed for matching chromaticity value to a target color. The SPD of reference color have two peaks. Color patches of target and reference color were displayed side by side on LCD. Distance between each color patch was 0.5 cm. Image size of color patches was 10 cm height and 2.5 cm width. Distance between LCD and observers were approximately 50 cm. The experiments were conducted in a dark room.

As an example of target color, a band-pass filter whose center wavelength was 570 nm and FWHM was 30 nm. As a reference color, four combinations of band-pass filter with center wavelength were chosen as follows; 550 and 600 nm, 540 and 610 nm, 530 and 630 nm, 520 and 630 nm (note that FWHM of 630 nm was 30nm and that of the others was 10 nm). There were few overlap between SPD of the target color and SPDs of third and fourth combination (520 and 630 nm, and 530 and 630nm) and the color patch of the target color was perceived as located in front of that of the reference color. However, the effect of depth perception was reduced in the case of the first and third combinations (550 and 600 nm, and 540 and 610 nm). As for other target colors, similar trends were observed. From these results, it is inferred that overlap of SPDs effects on depth perception.

PS2-84

Haze and Convergence Models: Experimental Comparison

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ABSTRACT

Outdoor images are usually prone to degradation caused by atmospheric scattering particles. Many dehazing methods have been proposed to minimize this degradation and recover the original scene contrast. Although several articles have reported the shortage of color fidelity in recovered scenes, none of the existing methods has deeply addressed this problem from a color point of view.

The haze model, which describes hazed scenes, is a non-wavelength based model. This implies that hue remains unchanged through dehazing, according to the hue definition of the used color space. This fact did not prevent the perception of dissimilarities between original and recovered colors. Thus, we proceeded by splitting up color components and evaluating the color saturation and hue shift.

In order to estimate accurately the prospective color shift, a complex scene was created inside a closed room with a controlled illuminant. Unlike outdoor scenes imaged in a foggy day, a simulated scene provides many advantages, like the possibility to reproduce infinitely the scene with the same conditions and the availability of the original image.

Once original saturations and hues and the recovered ones are located in the adequate color spaces, the color shift from original image is studied. Based on this knowledge, we investigate two methods for correcting the color shift: the first approach is based on color constancy principles, and the other one is based on a convergence model of color transparency, which subtracts the transparent filter covering a surface.

These transformations are directly dependent on the amount of covered fog and the initial assumptions of the correspondent dehazing method. This adjustment is applied as a post processing dehazing stage.

Since non-physical based methods enlarge the difference between the recovered and the original colors, they are excluded in this work. Although, the resiliency against color shift of physical based method is discussed.

Hyperspectral Reflectance Reconstruction Using a Filter-based Multispectral Camera

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ABSTRACT

In multispectral imaging field, three types of spectral cameras are commonly used: (1) a line-scanning hyperspectral camera, (2) a filter-based multispectral camera and (3) a trichomatic camera with known principal components of the spectral reflectances. Each of them has its own pros and cons. The line-scanning hyperspectral camera is time-consuming in its spectral image acquisition, whereas the filter-based multispectral camera cannot provide accurate hyperspectral data with its limited bands. The trichomatic camera cannot predict the spectral data in high precision when the principal components are unknown.

In digital archiving, hyperspectral data is useful for image restoration. In this study, a filter-based 8 band multispectral camera is used to extent its data from 8 band to 61 bands within visual spectra. The camera provides uncorrected achromatic image for each filter-band. Therefore, we have to write software to improve the accuracy of spectral estimation. We corrected its lighting uniformity, estimated multispectral tone responses using a 2nd order regression by not only achromatic samples but also color samples from a ColorChecker chart, interpolated its spectral data to 5nm interval using cubic interpolation and combined the results under four different light sources. The maximum color errors greatly reduced from 20.1 to 6.7 deltaE. PCA based method also were tested. The maximum color error was further decreased to 2.1 deltaE.

On the other hand, the spectral filters of the camera are switchable. However, if we switch the filters, the spectral images captured from different filter sets cannot align each other accurately. A Scale Invariant Feature Transform (SIFT) therefore is applied to align the spectral images spatially. It would still reduce the sharpness and in some case invoke color aliasing of the image. A wavelet based image fusion method therefore can be used to take spectral resolution from only one filter set and then to take low resolution spectral information from all filter sets.

More results will be reported in the full paper.

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Fujifilm Group is transcending its conventional business fields of “Imaging and Information” to transform into a company that contributes to the development of culture, science, technology and industry, as well as improving health and environmental protection across society. To help enhance the quality of life toward realizing a society in which people enjoy spiritual and material wealth, we will strive to realize our corporate philosophy through the three business fields of Imaging Solutions, Information Solutions and Document Solutions.

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SUGA Test Instruments, manufacturers, sells and provides services globally, portable and desk top, world-class colour meters, spectrometers, and unique & bench top gloss meters, haze meters and image clarity meters.
These colour appearance analyzers allow one to access and control the colour appearance properties of products and materials.
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NIPPON DENSHOKU INDUSTRIES CO.,LTD., is specialist for color measuring instruments.
It's been half a century since we have started to support the color management and will broaden our view and contribute to color business society.

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Since 1989, OPTIS has led the way in light simulation software. Our unique physics based simulation tools deliver the most accurate representation of optical and lighting systems and are fully integrated into the world leading CAD platforms. OPTIS solutions can also help you understand how color and spectrum work in your products and systems.

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Spectral Application Research Laboratory Inc. (SARLI) supplies a Spectral Imaging System (all own designs) which is able to examine the mixed state of natural and artificial materials more deeply. Our system consists of camera and drive device on sample side, and also a dedicated software application is built-in.

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Topcon Technohouse Corporation provides various types of light and color measuring instruments and contributes to the development of many industries.
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Canon

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Primary businesses of Integra Inc. are development, marketing and sale of computer software products and related services for engineering.
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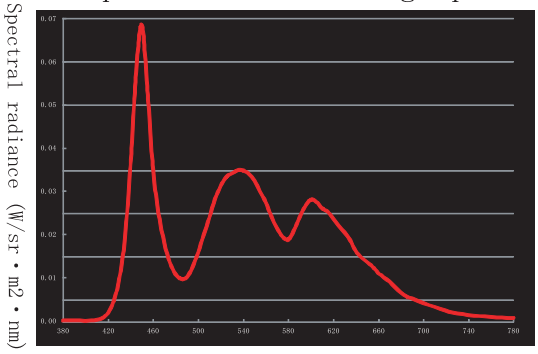
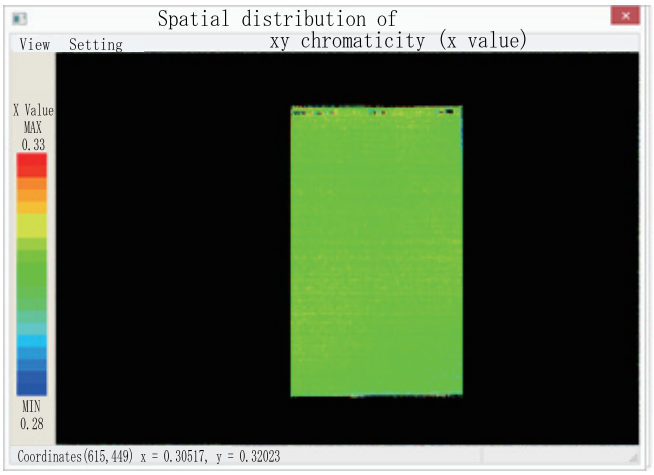
Measuring two-dimensional spectral information instantly

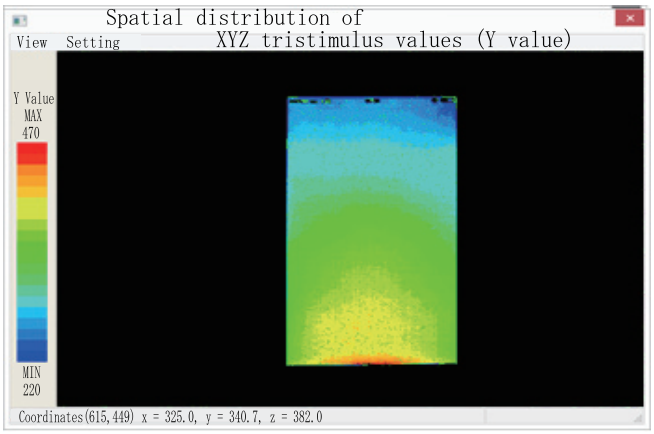
Spectral Color Imaging System

Digital camera image

Spectral radiance graph





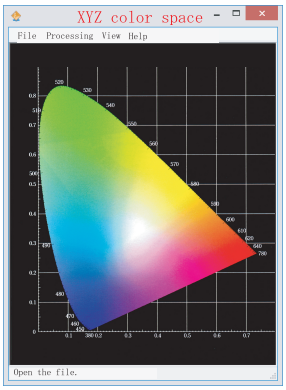


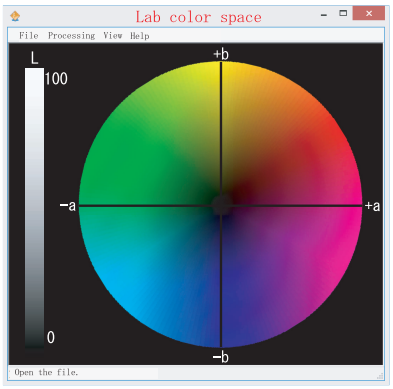
① Capable of acquiring spectral radiance every one pixel of the image

② Conversion to each color space coordinates (eg. XYZ)

③ Dispersed spectrally by 5nm in the wavelength range of 380nm - 780nm

④ Fast acquisition of spectral data (300,000 pixels: 1.8 seconds)





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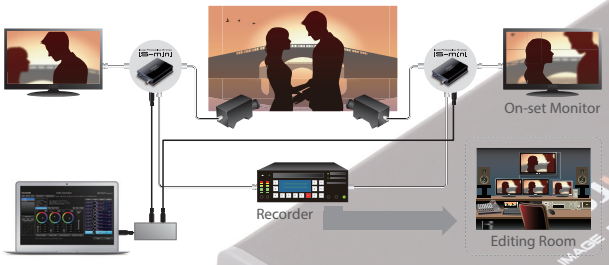

For color matching of multiple displays

Color matching of multiple monitors of various ages.

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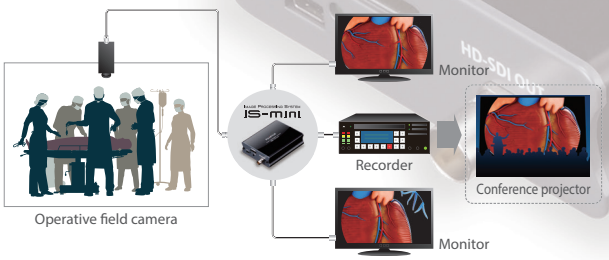
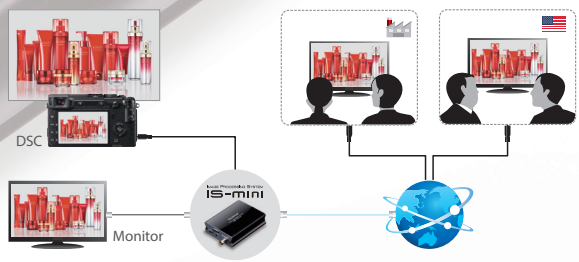


Faithful color reproduction of live images in different locations around the globe.



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and so on.

Suga's products answer your appearance issues.

Mt. Fuji is a symbol of the beauty of Japan and has been registered as an UNESCO World Heritage Site. Hokusai* drew inverted image of Mt. Fuji reflecting from a lake surface in his ukiyo-e (traditional Japanese woodcut print), expressing the beauty of the reflected image. Image Clarity Meter is capable of assessing the clarity of reflected (transmited) image in a numerical value.

Suga's products offer real solutions to today's colour appearance issues.

*Hokusai Katsushika (1760 – 1849) is a leading Japanese ukiyo-e painter, who was active during the late Edo period. He was an artist who continued to take on the challenges of creating new artistic expressions throughout his entire career, which spanned for almost 70 years from his debut as an ukiyo-e painter.

Image Clarity Meter
for Reflected or Transmited Image

Spectro Colour Meters
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Gloss Meter
Portable

Haze meter

Suga Test Instruments Co.,Ltd.

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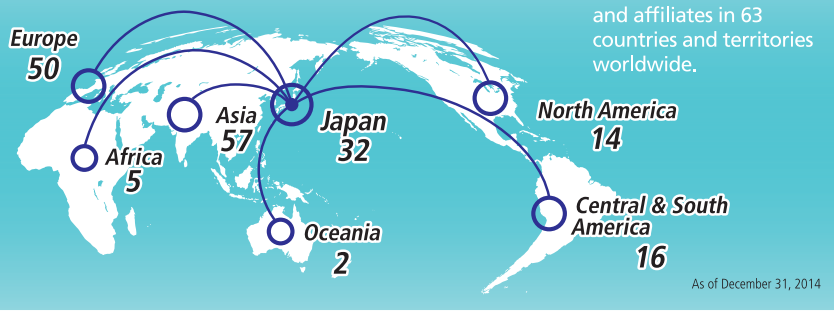

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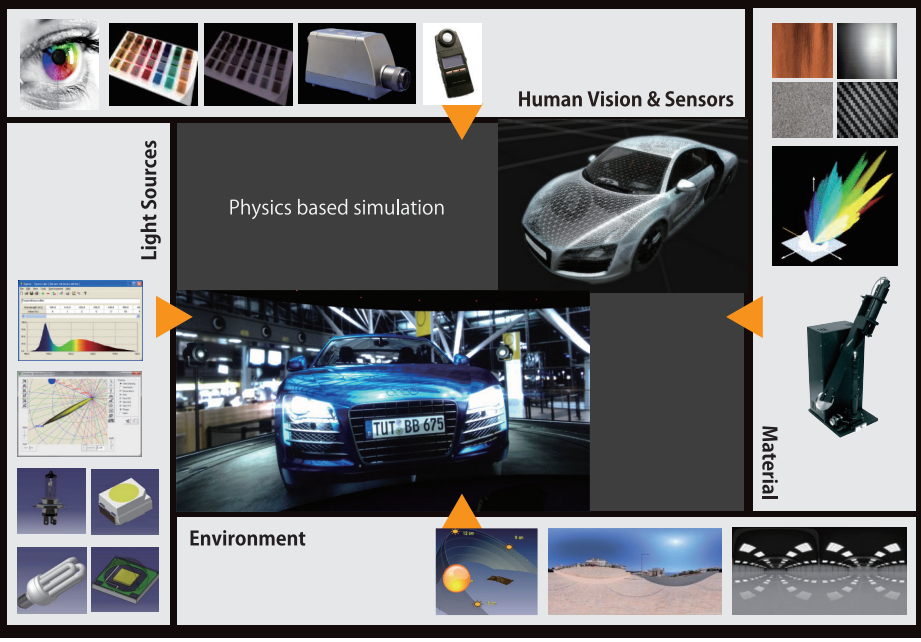

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Spectral Imaging system for visible range by Spectral Camera

SARLI
分光応用技術研究所

Spect-CAM-100vis

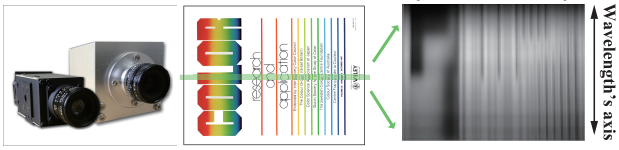
Abstract

This system is composed by Spectral Camera (Spect-CAM- lOOvis) and special software for 2nd dimensional color evaluation. Spectral Camera is newly developed including new small and mostly aberration free spectral imaging unit (Spect-lOOvis) and precise rigid scanning unit. This 2nd dimensional spectral measurement is tactical machine that serves you appropriately. Software is tuned for 2nd dimensional evaluation color (visible range) and describe nothing about general spectral evaluation.

Measuring example by Spect-CAM-100vis. This picture was taken by- integration calculation after multiplication by every wavelength's image and sensitivity function (sRGB).

Internal Spectral Imaging unit and Comparison data for measuring sample and acquisition result (spatial axis *wavelength's axis)

SPECT-100VIS | Sample data | Spatial axis



Spectral Imaging unit (Spect 200vis) and left unit is smaller one (Spect-100vis). This small type is used in Spectral Camera.

Area of green line's rectangle for magazine [Color Research and Application] can be captured in one shot by the camera. By scanning green rectangle area, all of 2nd dimensional spectral data can be captured.

Content for measuring and analysis by Spectral Camera and software

- Spectral Imaging acquisition (380-780nm) (Standard 1280* 2000 pixel * 960Ch (Wavelength's axis) A/D 16 bit resolution
- Transferring wavelength' s imaging data (380-780nm,each5,10,20nm) from original acquisition data, (approximately 0.4nm pitch)
- Calculation of reflection or transmittance data from raw data (light irradiated function * sample data* instrument function) by using reflection or transmittance standard.
- Drawing spectral curve for one point or area of Region of Interest (ROI) and ASCII data saving for more research.
- Calculation of RGB (sRGB or etc), XYZ .CIELab, (Illuminant standard A,C,D65, or synthesized light spectral curve).
- Color Image synthesizer by using Color matching function or sRGB function and your original sensitivity function.
- Option : Concentration's map of colorant or 2nd dimensional CCM, etc..

Spectral Application Res. Lab. Inc

E-mail info@sarli.jp Tel & Fax 053 523 - 9605
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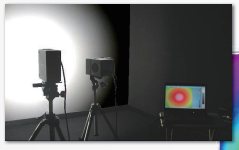
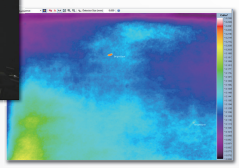
Smart and accurate imaging colorimeter



Measures spatial distribution of luminance/ illuminance/color of luminare/LED etc. and exports ray file to optical design software.



Measures pixel defects/luminous uniformity/ color uniformity of FPD/instrument panel etc. Automated inspection system available.

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G series, I series, Y series

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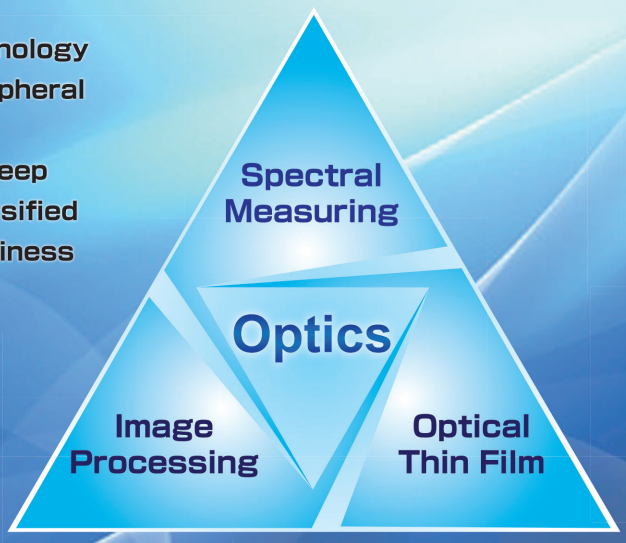
Optics in our core technology and enhanced with peripheral technologies, Topcon Technohouse keep responding to the diversified needs of extensive business fields.

2D Luminance Colorimeter

UA-200



Topcon Technohouse Core Technologies

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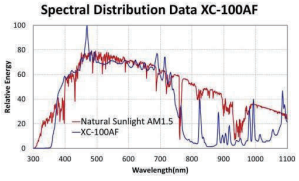
For Color checking precisely

For Color measuring accurately

Perfect light source for color evaluation

SOLAX XC-100/500 series

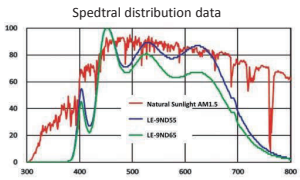
extraordinary color checking



Super High spec color rendering LED

SOLAX-iO series

portable sunlight to be available



SOLAX is the perfect color checking light source because…

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✓*Line spectrum free*

✓Spectrum as match as sunlight

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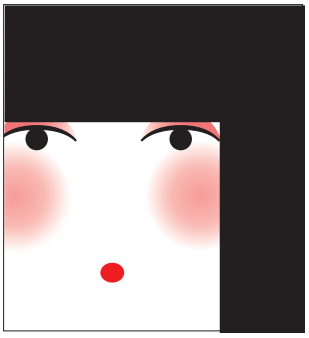

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