

# Multi-Disciplinary Challenges in the Measurement and Reproduction of Skin Colors

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## Goal

In this workshop our goal was to bring together practitioners and academics from a range of disciplines to explore the outstanding issues in the measurement, reproduction, and perception of skin, with a particular emphasis on skin imaging. We wanted to understand more deeply what the most pressing challenges are in this area, and stimulate cross-disciplinary collaborations that might help address these issues. In particular we wanted to bridge the gap between skin colour imaging and measurement in academic environments, with skin colour imaging in industry and medicine.

Specific goals were:

- To investigate methods and best practices for skin colour measurement, skin image capture, and reflectance prediction for skin images.
- To explore current and future industrial applications for skin measurement and reproduction.
- To identify requirements of skin image measurement and reproductions for medical applications.

## Organisation

We identified and invited 5 leading speakers, 2 from industry and 3 from academia, to present at the workshop. Topics covered included the physics and physiologically of skin analysis and synthesis, skin colour gamuts, uncertainty of skin colour measurement, skin measurement across different ethnicities, and practical aspects of skin imaging systems for dermatology. A complete list of speakers and details is provided in Appendix A. Each speaker had a space of 30 minutes for their presentation and discussions. The full itinerary is provided in Appendix B.

## Summary of outcomes

- The involvement of industry created an important focus on standards and challenges in the practical application of skin colour measurement.
- Academic talks highlighted the challenges in skin colour measurement, and novel methods for characterizing variability in skin colour across different racial groups.
- The presentations and discussions raised a number of interesting questions. Specific areas of interest were:
  - Evaluation of skin colour measurement for multispectral camera system
  - Skin colour database for different ethnic groups and aging
  - How to apply skin colour gamut for colour reproduction of 3D printing
  - Skin chromophore prediction for cosmetic industry
- The presentations, questions and discussion will feed into the work on skin databases around the activities of CIE TC 1-92, and the ICC medical image working group.

## Appendix A – Details of presentations

### **Fundamentals of skin color reproduction for tele-medicine**

*Francisco Imai; Canon USA, USA*

**Abstract:** This talk is going to cover how to characterize and model imaging systems for accurately capturing ground truth skin imaging and reproducing the appearance on displays emphasizing the need for a perceptual metric to assess the performance of the reproduction. Applications for tele-medicine on appearance of facial skin, endoscopy and odontology will be discussed.

### **A multispectral imaging system for dermatology studies**

*Wei-Chung Cheng; US Food and Drug Administration, Maryland, USA*

**Abstract:** A multispectral imaging system was developed to obtain the spectral imagery in the  $d/0^\circ$  lighting geometry. The system images skin in a  $\varnothing 65$  mm circle and reports the spectrum between 380 and 780 nm for each of the 113 thousand pixels. The sampling size of every pixel is approximately  $113 \times 113 \mu\text{m}^2$ . The illumination is a tunable light source diffused by an integral sphere. The detector is a fully calibrated scientific camera set up at 0 degrees. The system is driven by computer software to capture an image in 4 seconds and then generate the spectra within 30 seconds. Compared with typical spectrophotometers, the multispectral imaging system provides per-pixel spectral data of a larger area, which enable researchers to study spectral properties of skin disease including melanoma and other pigmented lesions.

### **Uncertainty of skin colour measurement and database**

*Mengmeng Wang; University of Leeds, UK*

**Abstract:** Skin colour is important for colour reproduction and skin disease diagnoses. For measuring skin colour, tele-spectroradiometers (TSRs) and spectrophotometers (SPs) are two widely used instruments for skin colour measurement. In this study, the short-term repeatability and skin colour distribution of ten and five locations of 188 subjects from four ethnic groups, including 86 Oriental, 79 Caucasian, 13 South Asian and 10 Africa, which measured by these two kinds of instrument were investigated. Each of the location was measured three times. The short-term repeatability was determined through the mean colour difference from the mean (MCDM), which is the mean colour difference ( $\Delta E^*_{ab}$ ) between each of the three repeat measurement and their mean CIELAB values. From the MCDM values of different instruments and ethnicities can see, the short-term repeatability of these two instruments is different. The MCDM value of TSR is about twice to the SP's. Apart from African group, the short-term repeatability of different ethnic groups is similar. The skin colour distribution of different ethnicities and instruments were investigated through plot the mean CIELAB value on  $a^*b^*$  and  $L^*C^*_{ab}$  planes. Comparing the measurement results of two instruments can see, the TSR's is lower in lightness than the SP's. The hue angle and chroma of two instrument's measurement results agrees well. The distribution of two instruments measurement results is similar. They both showed a trend that lighter skin colour is higher in lightness and lower in chroma, except the African group.

### **Skin colour gamut for different ethnic groups**

*Changjun Li; University of Science and Technology Liaoning, China*

**Abstract:** The gamut of surface colour was considered by Mike Pointer in 1980 and was refined by ISO in 2007. However, the skin colour gamut is much smaller than that. In this talk, the skin gamut for all ethnic minorities such as Caucasian, Chinese and Thailand and so

on, as a whole will be given and comparisons on gamuts from different ethnic minorities will be given as well.

### **Physics and Physiologically Based Skin Color Image Analysis and Synthesis**

*Mai Kuroshima and Norimichi Tsumura; Chiba University, Japan*

**Abstract:** Reproduced skin appearance such as color, texture and translucency depend on imaging devices, illuminants and environments. As a result of the recent progress of color management technology, imaging devices and the color of an illuminant can be calibrated by device profiles to achieve high-fidelity appearance reproduction. However, the high-fidelity reproduction is not always effective in the practical imaging systems used for facial imaging; therefore, additional functions for color, texture and translucency reproduction are required in high quality facial image reproduction. We named these functions as E-cosmetic functions, and we believe the E-cosmetic function should be physics based and physiologically based processing for high quality facial image reproduction. In this manuscript, therefore, physics and physiologically based image processing is introduced based on the extraction of specular, hemoglobin, melanin and shading information in the skin color image.

## Appendix B – Schedule

### Overview:

The workshop will start at **9.00 am** on **Friday 23<sup>rd</sup> October**, and finish at **12.00am** with a short break at **10.30am for coffee**. Each speaker will have up to 30 minutes to present their work, which includes time for both presentation and questions.

### Order of talks:

**Friday 23<sup>rd</sup> October**    ***Multi-Disciplinary Challenges in the Measurement and Reproduction of Skin Colors***

- 9.00 am**    *Welcome and Introduction*  
**Kaida Xiao**; University of Liverpool, UK
- 9.10 am**    *Fundamentals of skin color reproduction for tele-medicine*  
**Francisco Imai**; Canon USA, USA
- 9.40 am**    *A multispectral imaging system for dermatology studies*  
**Wei-Chung Cheng**; US Food and Drug Administration, Maryland, USA
- 10.10 am**    *Uncertainty of skin colour measurement and database*  
**Mengmeng Wang**; University of Leeds, UK
- 10.40 am**    **Coffee Break**
- 11:00 am**    *Skin colour gamut for different ethnic groups*  
**Changjun Li**; University of Science and Technology Liaoning, China
- 11.30 am**    *Physics and Physiologically Based Skin Color Image Analysis and Synthesis*  
**Mai Kuroshima** and **Norimichi Tsumura**; Chiba University, Japan