Color rendering and museum lighting

János Schanda, Peter Csuti and Ferenc Szabó

Virtual Environment and Imaging Technology Laboratory at University of Pannonia, Veszprém
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Overview

- Art preservation and lighting
- Historic overview of museum lighting
- LED lighting in museums
- Specialities with frescos
- Sistine Chapel frescos
- New paradigm for museum lighting
- Summary
Art preservation and lighting

- Lighting = irradiation = photochemical reactions + heating
- Visible and UV radiation:
  - shorter wavelength – higher photon energy
  - but: some pigments are sensitive to other wavelength as well (VanGogh – chrome yellow)
- Lighting for human perception
  - proper color perception of paintings
  - glare, modeling, etc. will not be discussed here
Historic overview on museum lighting

- Traditionally daylighting: sky-lights
  - High correlated colour temperature (CCT)
  - Changing levels and CCT
  - Damaging radiation
- Incandescent lighting
  - High IR content: heating
- Gas discharge lighting: lower colour rendering
- LED lighting: spectrum can be tailored at will

With the kind permission of Dr. Brad, Philis Ltd.
SSL lighting trends

- US: halogen retrofit LED lights
- Europe: specially built LED luminaires

Demonstration Assessment of Light-Emitting Diode (LED) Retrofit Lamps
Host Site: J. Paul Getty Museum, Malibu, California
Final Report prepared in support of the U.S. DOE Solid-State Lighting Technology Demonstration GATEWAY Program

J. Padfield, S. Vandyke and D. Carr, 'Improving our Environment'
http://www.nationalgallery.org.uk/paintings/research/improving-our-environment
Possibilities of LED lighting

- Large freedom in selecting the spectrum
- Easy dimming
- Long lifetime
- Possibility of flood-lighting but also lighting with projectors

National Gallery, London, see Padfield et al: [www.nationalgallery.org.uk](http://www.nationalgallery.org.uk)

Fontynont et al: [www.fraensrl.com/monaslisa.html](http://www.fraensrl.com/monaslisa.html)
Constrains of the lighting

- **Museum curators require**
  - Warm white light colour
    - CCT: 3000 K – 3500 K
  - Illumination < 200 lx
  - Colour rendering: $R_a > 85$
  - No radiation below 420 nm (photo-degradation)
  - No radiation above 750 nm (heating)
Colour rendering (CRI)

- Evaluation based on CIE 13:3
- Possibility for
  - colour preference: entertainment
  - colour fidelity: education, art preservation

- Problem with test samples:
  - Museum object pigments differ from pigments used in CRI calculations
Pigments for color rendering calculations

- CIE colour rendering index Munsell sample selection:
  - 8 non-saturated
  - 4 saturated
  - Caucasian complexion + leaf green

- 15 Color Quality Scale Munsell samples

- 17 CRI2012 artificial samples

- Pepler and Khanh have shown that oil paint pigment would give different colour rendering indices
First trials to determine spectral reflectance of frescos and renaissance paintings

- Reflectance spectra
  - at Esztergom castle
One of the pictures at the Hung. Museum of Fine Arts

Pierre Francesco Foschi – Holy Family with the Infant Saint John

1. Blue veil
2. St. Mary's red dress under the belt
3. Baby Jesus's face
4. St. Joseph's yellow scarf on his right shoulder
5. St. Joseph's light purple dress on his right arm

Reflectance, %

wavelength [nm]
Reflectance measurements at the Sistine Chapel

Photocopy from „Die Sixtinische Kapelle”, SCALA 2011, Florence, Italy, with marks showing points of measurements
Sistine Chapel samples

- More than 200 pigment samples measured spectrally
- 15 non-redundant samples selected
  - Grouped according to their colour constancy
Color constancy of samples

- Colour Constant Samples
- Colour Neutral Samples
- Colour Inconstant Samples

Color inconstant sample spectra look similar to CRI2012 samples
Selected LED spectra
Optimization

- New paradigm:
  - Reproduce with illumination of 3500 K the colours as seen by the artist under the light of creation: for renaissance paintings

NATURAL DAYLIGHT
Comparing new paradigm with CRI

Planck 3500 K, no optimisation

Smet-Whitehead samples
Conclusions

- With LEDs one can tailor the illumination as requested
- Light can be produced that is least harmful for pictures
- There are three paradigms to choose from
  - Colour fidelity
  - Colour preference
  - Optimum corresponding colours
Thanks for your kind attention!

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