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A Spectral Database of Commonly Used Cine Lighting

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Outline

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Motivation: *Why there is a need of a spectral database of cine lighting?*

Methods: *Which standardized measurement methods exist and which one did we use?*

Measurement Setup: *How can a fast and reproducible measurement geometry be achieved?*

Measurement Process: *Which measurement steps were fulfilled?*

Results: *What sample results did we measure?*

Error Discussion and Limitations: *What did influence our measurements?*

Applications: *First applications for a better color reproduction.*

Motivation

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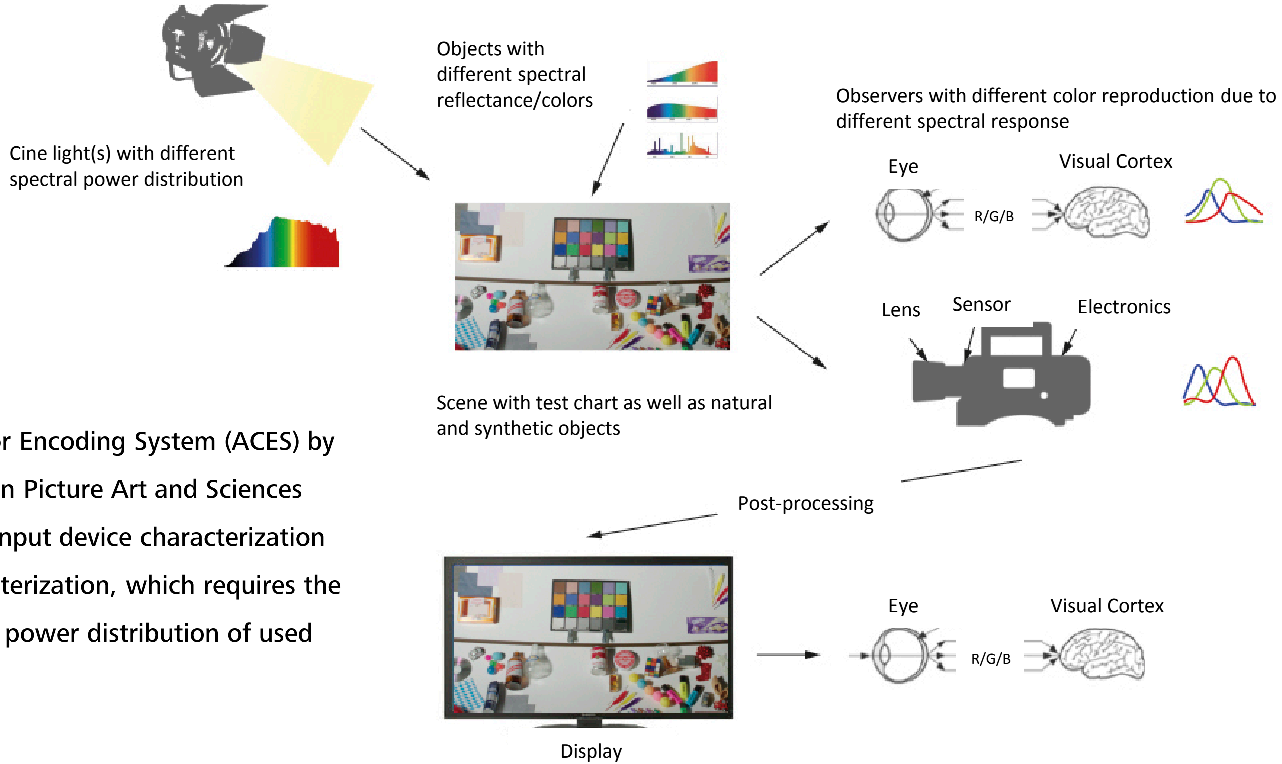
- Currently no public available numerical database with spectral power distributions of commonly used cine lighting exists.
- Manufacturers of bulbs and cine lighting publish spectral power distributions only as graphs and the measurement setup and geometry is often not reported.

…, but for a spectral based approach to movie color reproduction we must have the spectral power distribution…

Motivation – A Spectral Based Approach to Movie Color Reproduction



E.g. the Academy Color Encoding System (ACES) by the Academy of Motion Picture Art and Sciences uses a spectral based input device characterization (IDT) as camera characterization, which requires the knowledge of spectral power distribution of used lighting.

Motivation – Other Benefits of a Spectral Database

- Comparison of different lighting

- Derivation of colorimetric data such as:

  - Correlated Color Temperature (CCT)
  - Color Rendering Index (CRI)
  - Representation in different color domains, like CIE XYZ or **u'v'** coordinates of the CIE 1976 Uniform Color Scale (UCS) for 2° standard observer

- A certain light might be evaluated against samples of this dataset, in order to detect maladjustment or ageing effects.

Measured Lighting

- We measured the spectral power distribution (SPD) of commonly used cine lighting related to following light emitting principles:
  - Thermal radiator, i.e. Tungsten (TU)
  - Fluorescence (FL)
  - Metal halide gas discharge (HMI)
  - Light emitting diode (LED)
- Manufacturers of measured lighting are ARRI, Bron Kobold, Dedolight and Kino Flo.

Methods – Existing Standards

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- A method commonly used by manufacturers of lighting technology is a measurement geometry setup with an integrating sphere. It is specified by the International Commission On Illumination (CIE) and known as an 8° geometry.

- One Measurement Condition for that method: the sum of areas of entrance and exit ports of the sphere must be less than 5 % of the whole sphere's area.

- This condition leads to a very huge sphere, which is not applicable, because some cine lighting have large dimensions. Furthermore, the whole radiance (including light coming from the edge of the lighting's exit port) is integrated.

Methods – Existing Standards

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- Based upon ISO 3664:2000 standard viewing condition 45°/0°, we used and propose a measurement setup and measurement procedure to ensure a quick and reproducible measurement process.

- 45°/0° geometry was chosen, because this geometry is a good approximation for the widely used 45 degree portrait lighting setup used in photography and movie production.

- Additionally, this geometry has the advantage that only a small solid angle of the lighting cone reflected by the object is measured which is an adequate representation of the real scene.

Measurement Setup - Geometry and Placed Components

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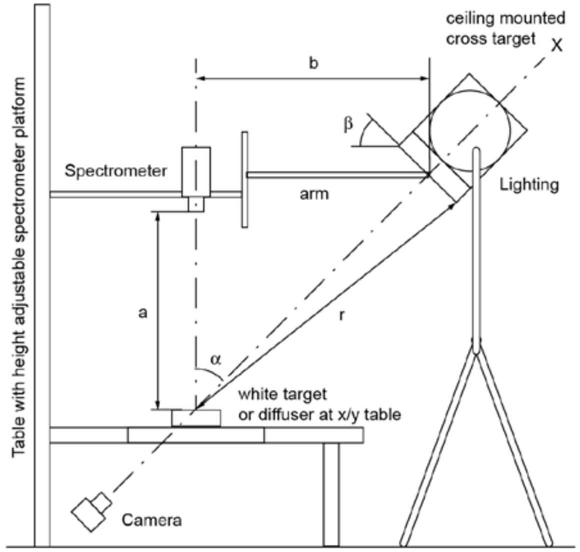
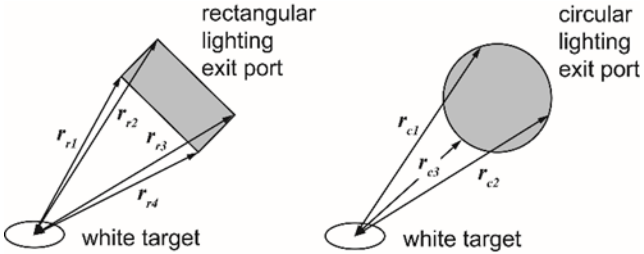




a vertical distance from the white patch surface to the front of the spectrometer lens

b horizontal distance from the optical axis of spectrometer to the center of the maximum vertical illumination aperture

r distance from the white patch surface to a corner edge point of the lighting exit port (r_{r1}-r_{r4} or r_{c1}-r_{c3})

α angle between optical axis of spectrometer and the surface normal at the center of light source aperture

β angle between the plane defined by the edge points of light source exit port and the horizontal plane

Measurement Setup -
Used Parameters and Components

- We used a distance from white target to spectrometer ***a*** =1m. The horizontal distance ***b*** is variable in a range of 1 to 2.5 m related to dynamic range of spectrometer and power of lighting.

- The white target we used is made of polytetrafluoroethylene (Zenith-Polymer by SphereOptics).

- The spectrometer is a PhotoResearch PR 650, which measures the radiance (W/(sr m^2 nm)).

- All measurements have been performed 15-30 min after the lighting was switched on at a temperature of 23°C and approximately 30% relative humidity.

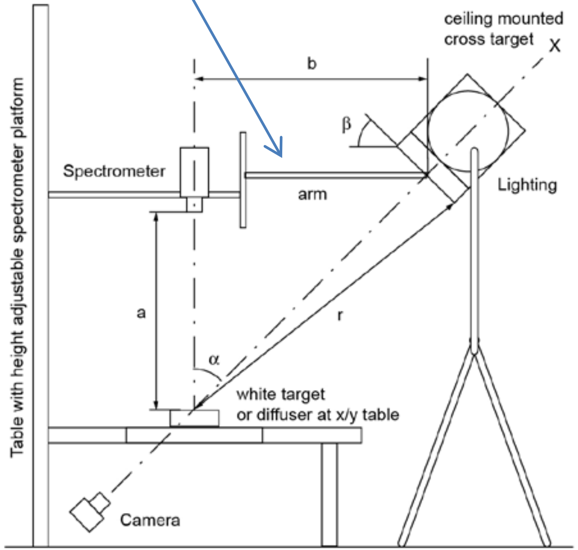
Measurement Process - Utilities and Steps

Image of centered lighting exit port

Image of lighting exit port to be centered after power on

1) Adjust length and position of arm for a given distance of **b**

Image of cone end of arm centered at cross target



2) Adjust lighting position to center of camera image which is congruent to cross target

Iterative loop

3) Horizontal/vertical adjustment for maximum intensity at patch center (with diffuser in front of camera)

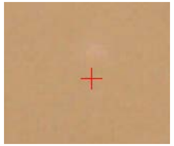
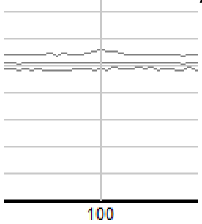


Image with diffuser in front of camera



Related Intensity Distribution

Results

- Several lighting can be used in “spot” or “flood” mode, we measured both positions; others are equipped with removable diffusers, measurements with/without diffuser were done; if variable power supplies exist, a measurement for 100% and 50% was done.

- Measured SPDs preparation and representation:

  - The measured SPDs have been post-processed in order to correct the white patch spectral reflectance. Every SPD of the database is an average of 100 single measurements captured during a period of at most 5 minutes.

  - Absolute (with related distances r_{r1}-r_{r4} or r_{c1}-r_{c3}) and normalized SPDs are available.

- In next slides random samples of measured radiances (absolute and normalized) will be shown.

- For selected measurements also a comparison of radiances related to ideal black body or standard D illuminants is shown as well as deviations for **u’v’** derived from the specified CCT values of the manufacturer.

Results – Overview of Traditional Lighting

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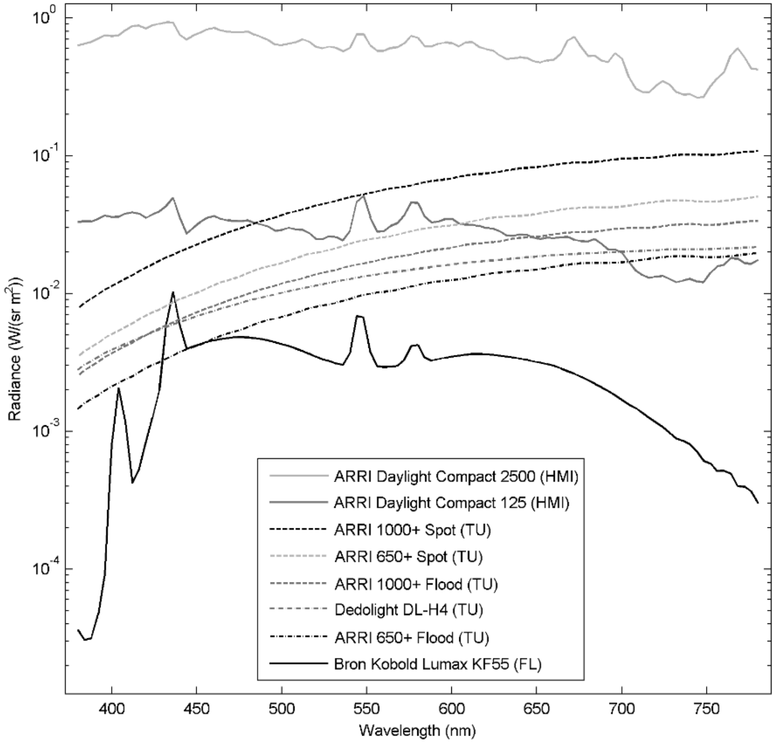

- The left Figure shows random samples for spectral radiances of traditional Tungsten, fluorescent and HMI cine lighting.
- It contains 3 ranges of magnitude in power
  - from low power fluorescence lighting (Bron Kobold Lumax KF 55),
  - to medium power Tungsten (ARRI 650/1000+ and Dedolight DL-H4) and HMI lighting (ARRI Daylight Compact 650),
  - and up to high power HMI lighting (ARRI Daylight Compact 2500).
- For ARRI 650/1000+, the variation for the Fresnel lens exit port at positions for spot and flood is shown (spot/flood).

Results – Tungsten Lighting

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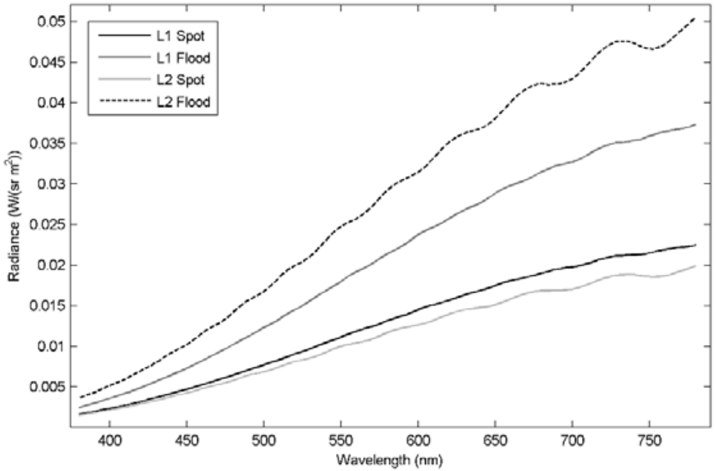

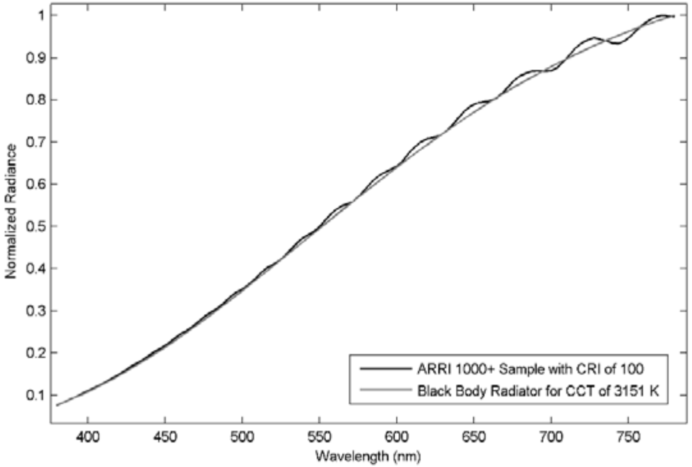

- Left Figure shows two ARRI 650+ spectral radiances, in which one light L1 is well adjusted (L1 Flood, L1 Spot) and the other one L2 is maladjusted (L2 Flood, L2 Spot)
- Right Figure shows the normalized radiance and CRI of one ARRI 1000+ sample at spot position and the ideal black-body radiation emitter for the correlated color temperature.
- The ripples in spectral radiance we found are significant in the upper range of visible spectrum and much more distinct for lighting with Fresnel lens exit ports. The reason for that might be subject to future research.

Results – HMI Lighting

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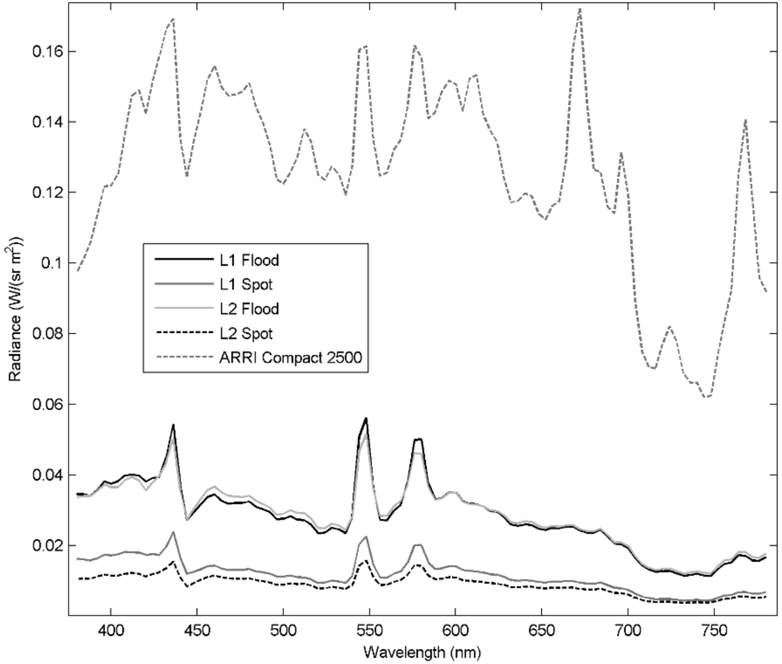
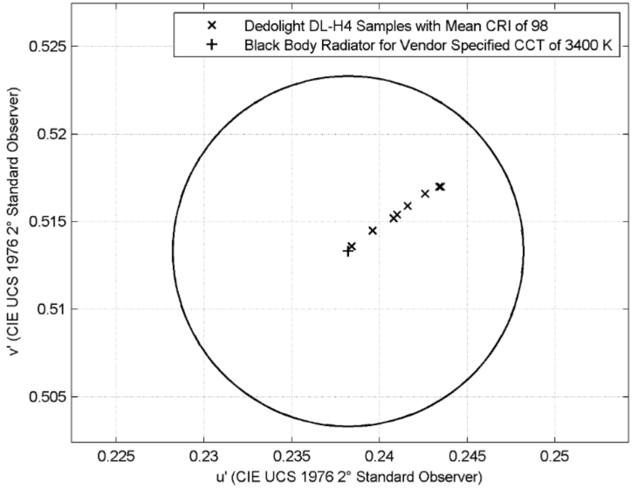
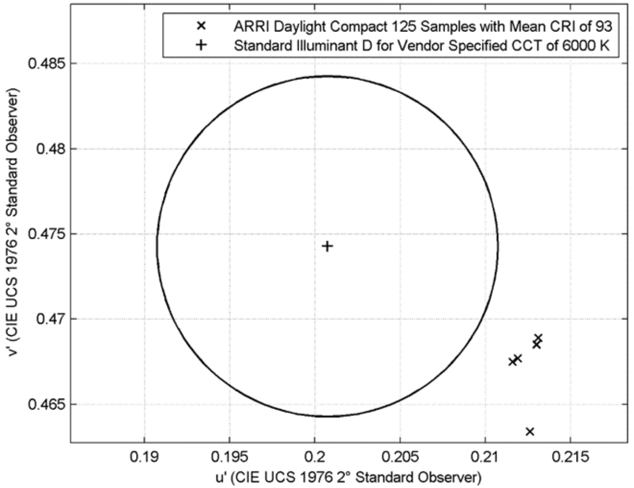


- Left Figure shows the spectral radiances of ARRI Daylight Compact lighting, one Compact 2500 sample at light exit port flood position and two Compact 125 samples L1 and L2 at spot/flood position.
- It shows different local maxima and peak ratios for Compact 2500 and Compact 125.

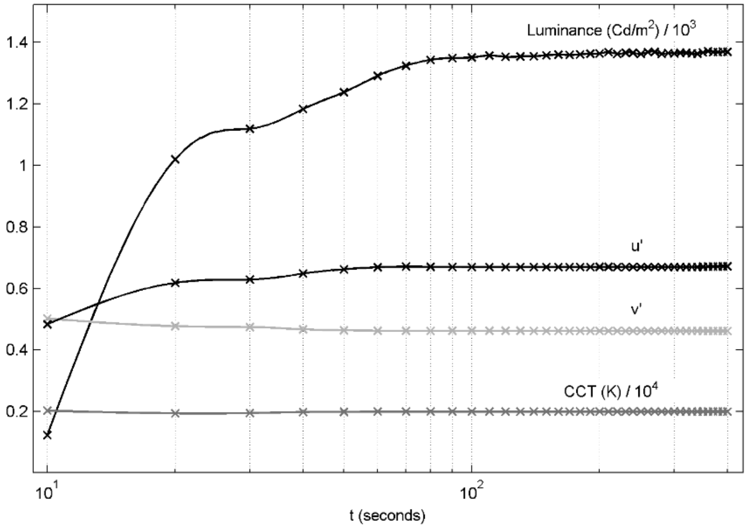
Results – HMI vs. Tungsten Lighting





- For Tungsten Lighting all CCT values as well as **u'v'** coordinates turned out to be close to the value specified by the manufacturer.
- Left Figure shows the **u' v'** values for the manufacturer specified CCT and a set of Dedolight DL-H4 samples at flood position.
- The circle has a radius of one just noticeable difference (JND) of 0.01 around the **u'v'** coordinates of the manufacturer specified color temperature for this lighting (same in right figure).
- Right Figure shows ARRI Compact 125 SPDs. This HMI lighting samples are in general outside of the JND of 0.01 of the equivalent standard D illuminant daylight color temperature based values specified by the manufacturer.

Results – HMI Lighting Power On Phase



- Measurements were done during the power-on phase to evaluate the transient phenomenon.
- Above Figure shows the luminance, the CCT, and the **u'v'** coordinates of the first 6.5 minutes after power-on for an ARRI Compact 1200.
- A stable state is reached for the CCT and **u'v'** after approx. 2 minutes and for luminance after 4 minutes.

Results – Fluorescence Lighting

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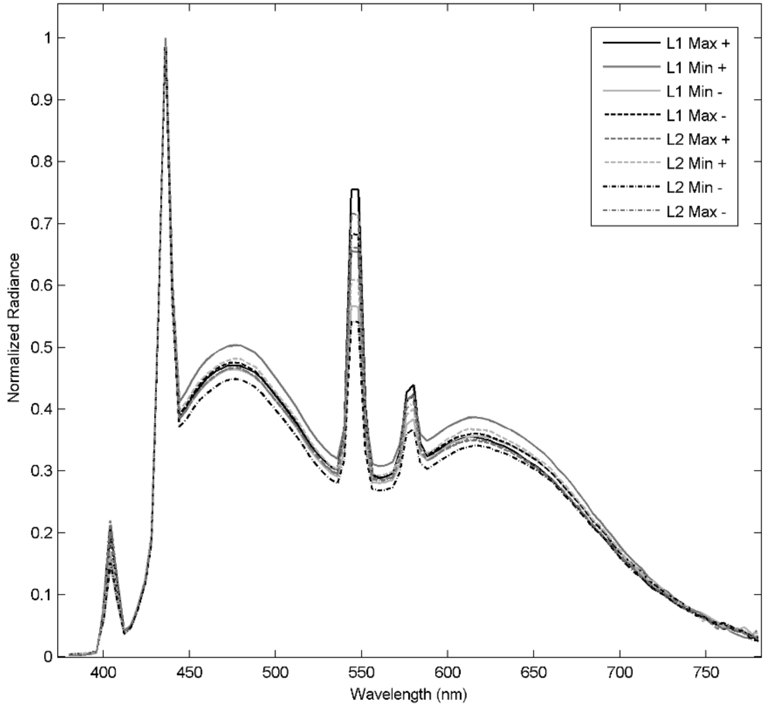
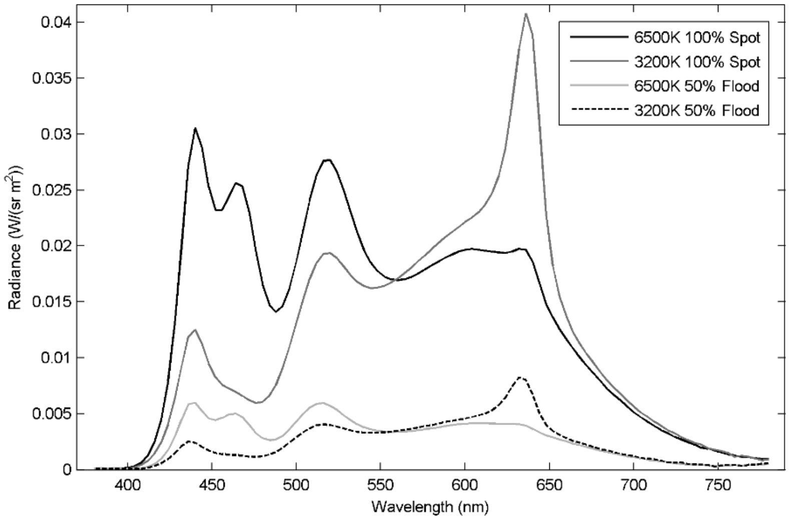


- Left Figure shows normalized SPDs of Bron Kobold Lumax lighting (two samples L1 and L2) at two different power steps, min indicates the lower one and max the upper one. Measurements labeled with + were done with and labeled with – were done without an interchangeable reflector.
- The SPDs show the fluorescent lines at constant wavelengths, but with different spectral radiances.
- This variation of radiances is mainly influenced by variance of doping of the tubes' fluorescent layer and the spectral reflectance of the reflector.
- Also this influences the chromaticity coordinates, the UCS coordinates are outside of the reference coordinates for the manufacturer specified color temperature for standard D illuminant daylight.

Results – LED Lighting



- LED based lights allow the variation of the CCT in a wide range of CCTs between those of typical Tungsten lighting up to standard D illuminants.
- The above Figure shows SPDs of an ARRI L5-C sample of a LED based lighting for CCTs of 3200K and 6500K, with 100% and 50% power, and at spot/flood position.
- Different peak ratios for 50% and 100% can be observed. The influence of the changed inner temperature must be further investigated.

Error Discussion and Limitations

- Geometric Errors:
  - Deviation of 45°/0° observing condition
  - $\boldsymbol{r_{c1}}$-$\boldsymbol{r_{c3}}$, respectively $\boldsymbol{r_{r1}}$-$\boldsymbol{r_{r4}}$ allows an estimation of observing angle deviation
- Radiometric Errors:
  - Used white target is a non ideal Lambert diffuser, due to rotation variance of reflected intensity; we use a 8° measured spectral reflectance for SPDs preparation which are measured with a 45°/0° geometry.
  - Different scattering by surface roughness and variable angle of incidence especially for huge light exit ports
- Insignificant Errors:
  - We ensured a signal-to-noise ratio of 10^5:1.
  - Scattering light in measurement setup was at least 4 orders of magnitude less than signal.

Applications – Estimation of Spectral Response

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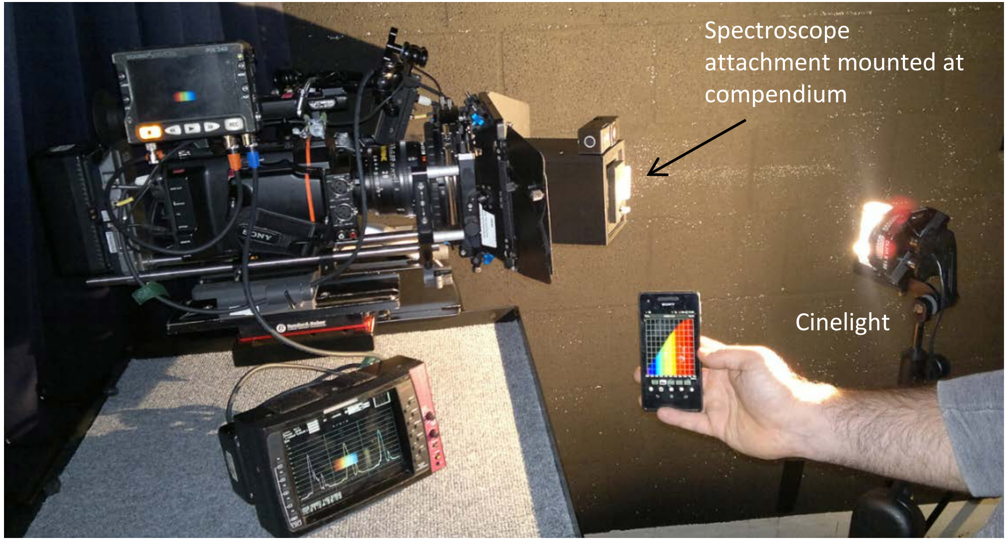

- We developed a spectroscope attachment to estimate the spectral response of camera systems which requires known SPD of illumination. This spectral reference data can be taken from our database.

Applications –
Spectral Based IDT Profiles

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- Also we developed a IDT profile creation service which allows the definition of lighting SPDs. This spectral reference data can also be taken from our database. Images above are IDT profiled image samples of a ARRI Alexa with a Zeiss UltraPrime (left) and a Bausch & Lomb lens (right) and a scene illumination with a Tungsten lighting.

OPEN FILM TOOLS

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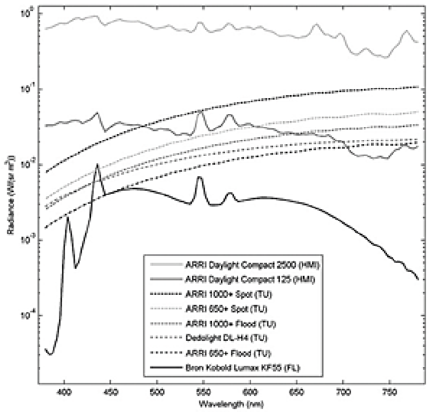
INTRANET

Hochschule der Medien » Open Film Tools » English

- Overview
- Camera-Characterization
- Publications
- Acknowledgement
- Contact

Samples of spectral power distribution

We have measured different lights and have compiled some sample files for the spectral power distributions. With the following link you can get the sample data. Either as a Zip file containing all samples and constraints and some information about the measurement setup for each shot.



General information files contain information for all lamps, while the sample data itself is ordered by light type like Tungsten, HMI, Fluorescence or LED and the manufacturer. The measurements are shared as one file per manufacturer and light type containing the measured raw values of the spectrophotometer as well as a file normalized to the highest peak over all lights contained in this file.

- OFTP_full-sample-package.zip (Archive containing all samples and general information, contains all files the following Zip files contain)
- OFTP_general-information.zip (Archive containing constraints, information to the setups and naming scheme)

Tungsten

- OFTP_Tungsten_Arri.zip

A Spectral Database of Commonly Used Cine Lighting – The Download

- The database is available at:

  www.hdm-stuttgart.de/open-film-tools/english/cinelight_spectra

- You can download absolute and normalized spectra.

Conclusion

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- We presented a spectral database of commonly used cine lighting.
- The measurement setup is based upon ISO 3554:2000 and allows a quick and reproducible measurement setup and process.
- The database is available at:

  www.hdm-stuttgart.de/open-film-tools/english/cinelight_spectra

- First Applications were shown using this database for an estimation of camera spectral response and ACES IDT profile creation.

Acknowledgements

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  - CinePostproduction GmbH
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