EMPIR Call 2020 – Fundamental, Industry and Normative

Selected Research Topic number: **SRT-n10**
Version: 1.0

Title: Implementation of high-dynamic-range imaging systems in standards for glare evaluation and luminance distribution measurement

Abstract

Luminance distribution measurements with high dynamic range (HDR) are required for various applications, e.g. new LED- or laser-based car headlights, light pollution, glare evaluation of indoor and outdoor scenes, and scattering surface reflectance. Both imaging luminance measurement devices (ILMD) and cost-effective devices like digital single-lens reflex (DSLR) cameras are often used for such assessments. An HDR-mode is achieved by digital post processing of image sequences, which lacks standardisation and uncertainty statements. Therefore, proposals addressing this SRT should aim at the development of SI-traceable standard methods for the evaluation and calibration of HDR luminance imaging and at the standardisation of the determination of instrument performance characteristics, including associated uncertainties.

Keywords

Luminance, HDR, ILMD, DSLR, spectral mismatch, glare, light pollution, stray light

Background to the Metrological Challenges

Everyday cameras (e.g. as those in smartphones) offer an HDR-mode by means of post processing. The proprietary algorithms align and combine images captured adjacent to another by means of registration of features (e.g. using autocorrelation). These algorithms however are dedicated to reducing the noise in dim areas of a photo in terms of an artwork, which also includes several other corrections (e.g. stabilisation, white balance, gamma curve, etc.) and thus cannot be considered a luminance measurement. DSLR cameras are widely used for field imaging luminance measurements (e.g. obtrusive light, light pollution, glare from daylight) but the devices present some issues, namely spectral mismatch and digital pre-processing of sensor readings by the firmware, e.g. into a raw-image data format. The spectral mismatch and the usage of filters introduce a high deviation and thus uncertainty of the luminance measurements.

ILMDs are increasingly used for luminance distribution measurements with high dynamic range, but the technology is leaping ahead of the established metrology. International Commission on Illumination, CIE, identified this as an issue and added a need for research on this topic “Metrology for HDR luminance” in their research strategy. Additionally, the ongoing EMPIR project 18SIB03 BxDiff identified a need for reliable HDR imaging near the specular angle in BRDF (Bidirectional reflectance distribution function) and in BSSRDF (Bidirectional scattering-surface reflectance distribution function) measurements. Within 19NRM02 RevStdLED, ILMDs are a key enabling technology for efficient characterisation of LED lighting products, but that project does not consider HDR mode.

Lighting application standards specify minimum luminance values for visual tasks (EN 13201-2:2015 *Road lighting. Performance requirements*) or maximum values for glare sources (EN 12464-1:2011 *Light and lighting. Lighting of work places. Indoor work places*) that must be evaluated in the field. Additionally, the European standard EN 17037:2019 (*Daylight in buildings*) proposes the use of an HDR imaging device using a fish-eye lens for verifying the daylight glare probability for site measurements. For measurements according to the new CIE recommendation CIE 232:2019 “Discomfort Caused by Glare from Luminaires with a Non-Uniform Source Luminance”, a high spatial resolution and a high luminance resolution is required.

For the measurement of relative luminance distribution as used for glare evaluation, it is necessary to know the relative spectral responsivity to estimate the uncertainty from a spectral mismatch. DSLR colour channels exhibit a large spectral mismatch to the CIE standard observer and a white balance correction does not help

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in case of light sources with different spectra (e.g. daylight, lamp, screen) or if the luminance of illuminated non-grey objects (e.g. colourful items as well as pale surfaces) is relevant.

An HDR-luminance image obtained from a sequence of images is influenced by different aspects of transient variations such as modulated illumination, variations in the scene, or continuous movements of the ILMD (e.g. inside a near-field goniophotometer) as well as other instabilities (due to e.g. handheld measurement, driving car, or air-borne method). If the image sequence represents a series of different integration times, the dark noise, amplifier glow, and smear effect can be reduced. But for scenes of high dynamic contrast, images with long integration times are likely to include blooming effects from highly overexposed regions which need to be detected.

Therefore, further research must be carried out to support the use of HDR imaging systems in luminance distribution measurements in order to achieve a higher level of confidence. In addition, it is necessary to have a better knowledge of the limitations of different types of instruments, and to calibrate these to evaluate and validate HDR-luminance measurements. Manufacturers need a clear metric for an HDR-mode in luminance imaging with reliable post-processing algorithms that they can refer to.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on metrology research necessary to support standardisation in traceable measurement of luminance distribution and glare assessment using HDR imaging systems.

The specific objectives are

1. To identify limits of detection, photometric and spatial resolution, dynamic range (including non-linearity and internal stray-light), and spectral mismatch for different types of instruments available for the measurement of luminance distribution (e.g. ILMD, DSLR). Additionally, to define the requirements for a traceable instrumentation and to develop luminance test and calibration standards to assess scattering and spectral mismatch.
2. To develop a strategy for the evaluation, validation and traceability of HDR-luminance measurements. Additionally, to develop and validate procedures for the calibration of different types of instruments and to demonstrate the inter-comparability of HDR luminance and glare assessment for those.
3. To propose a harmonised metric (i.e. an algorithm) able to i) generate an HDR-luminance image from a sequence of multiple raw images, which is traceable to the SI; and ii) enable traceability of relative images scaled to one or few traceable spot measurements of the scene.
4. To develop guidelines for the determination of uncertainty budgets of HDR luminance imaging measurements of single pixels and integral values (evaluation region, illuminance) as well as of glare assessment. This should also include relevant quality indices and test methods related to HDR luminance imaging and glare assessment. The guidelines should be made available to the CIE together with a proposal for supplementing the international standard CIE S 023:2013 (ISO 19467).
5. To contribute to the standards development work of CIE Division 2, CEN/TC and IEC to ensure that the outputs of the project are aligned with their needs, communicated quickly to those developing the standards and to those who will use them, and in a form that can be incorporated into the standards at the earliest opportunity.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Regulatory body or Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects. The proposal must name a “Chief Stakeholder”, not a member of the consortium, but a representative of the user community that will benefit from the proposed work. The “Chief Stakeholder” should write a letter of support explaining how their organisation will make use of the outcomes from the research, be consulted regularly by the consortium during the project to ensure that the planned outcomes are still relevant, and be prepared to report to EURAMET on the benefits they have gained from the project.

Proposers should establish the current state of the art, and explain how their proposed research goes beyond this. In particular, proposers should outline the achievements of the EMPIR projects 18SIB03 BxDiff and 19NRM02 RevStdLED and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.8 M€, and has defined an upper limit of 1.0 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution across all selected projects in this TP.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the lighting sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically, the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work.

Time-scale

The project should be of up to 3 years duration.

Additional information

CIE identified this topic as one of their priorities. Details are available at:

https://msu.euramet.org/current_calls/pre_norm_2020/documents/cie_priority_002.pdf