Potential European Partnership on Metrology
Call 2021 – Green Deal and Normative

Selected Research Topic number: **SRT-n08**
Version: 1.1

Important information about these documents

This call is being held ahead of any agreement from the Commission that the relevant funding will be available. At present the relevant legislation is still under discussion in both Council and Parliament, and there is no certainty on the detailed arrangements for funding selected projects. The funding of any selected project, and the terms and conditions of participation in the projects, are dependent on completion of the legislative process and the subsequent contractual processes between the European Commission and EURAMET. Proposers submit to this call at their own risk.

Background

Last year, EURAMET submitted a draft proposal to the EC for a further research programme to be established under article 185 of the Treaty on the Functioning of the European Union (TFEU) to follow on from EMRP and EMPIR. This was published by the EC at https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/european-partnerships-horizon-europe/candidates-digital-industry-and-space_en

The initiative would be called the European Partnership on Metrology and would aim to create, by 2030, a sustainable and effective system for metrology at European level that ensures Europe has a world-class metrology system that:

- Provides metrology solutions, fundamental metrological reference data and methods, offering fit-for-purpose solutions supporting and stimulating European innovation and responding to societal challenges.
- Supports and enables effective design and implementation of regulation and standards that underpin public policies that address societal challenges.

The Commission commissioned an impact assessment into this proposal and 11 others in similar priority areas, and, based on those findings, published their own proposal for the Partnership, their response to the impact assessment and a draft of the Decision on 23rd February 2021. See:

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:89:FIN

https://ec.europa.eu/commission/presscorner/detail/en/ip_21_702

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021SC0035&qid=1614677899327

That draft Decision is currently under discussion in the European Council and the European Parliament.

Under the assumption that the Council and Parliament pass the basic act which would form the legal basis for this research programme, and that the participating countries named in the Draft Decision submit the required commitment letters, EURAMET is publishing these potential Selected Research Topics and draft guidance notes. These documents are not approved by the Commission nor will they lead to a binding decision by EURAMET e.V. for any further negotiation or funding. All published guides and templates are subject to amendment by the EC and EURAMET e.V. as further information becomes known.

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Title: Support for the standardisation of luminance distribution measurements for assessing glare and obtrusive light using high-dynamic-range imaging systems

Abstract

A high dynamic range (HDR) measurement of luminance distributions is required for various applications (e.g. new LED- or laser-based car headlights, obtrusive light, sky glow, road lighting, and glare evaluation). Both imaging luminance measurement devices (ILMDs) and red-green-blue (RGB) sensor cameras that are based on a colour filter array, are often used for such assessments. HDR luminance images are achieved by severe digital post-processing of image sequences, which lacks standardisation and uncertainty statements. The proposal should aim at the development of SI-traceable methods for the evaluation and calibration of HDR luminance imaging and at the standardised characterisation of the instrument performance, including associated uncertainties. In addition, the need for reliable evaluation, validation, and traceable calibration of measurements should be addressed, along with an awareness of the limitations, especially for critical areas of society (such as traffic safety and security surveillance).

Keywords

luminance, HDR, stray light, ILMD, RGB sensor based cameras, spectral mismatch, obtrusive light, glare, daylight, road lighting

Background to the Metrological Challenges

Measurements with ILMDs have become increasingly common in standardisation and regulation in recent years, however the field is complicated, and the technology is far ahead of the established metrology. CIE submitted two documents [1,2] to EURAMET identifying a "*lack of traceable SI calibration, poor long-term stability, and inadequate relative spectral responsivity*" and "*the calibration and characterization of HDR-cameras used for luminance distribution measurements and glare evaluation"* as research priorities. As such, further research is necessary for defining calibration and evaluation conditions and improving guidance on the uncertainty evaluation for luminance distribution measurements and glare assessment. Establishing a firm metrological foundation for the measurement of light and lighting in this category, could also put a sharper focus on the social problems related to glare (such as traffic safety and security surveillance) and decrease workplace inefficiency caused by glaring work lighting. Moreover, the characterisation and assessment of obtrusive light and sky glow is an important application of HDR imaging systems for luminance distribution measurements, which is expressed in the 2019 revision of EUs Green Public Procurement Criteria for Road Lighting and Traffic Signals.

The document CIE 232:2019 "Discomfort Caused by Glare from Luminaires with a Non-Uniform Source Luminance" states that a high spatial resolution and a high luminance resolution is required to determine the average source luminance and its position in the field of view. In terms of measuring relative luminance distribution, it is necessary to know the relative spectral responsivity to estimate the uncertainty from a spectral mismatch. In contrast to photometric devices, the colour channels of low-cost RGB sensor based cameras exhibit a large spectral mismatch to the CIE standard observer and typical adjustments using white balance correction do not help in light sources with different spectra (e.g. daylight, sky glow, lamp, screen) or if the luminance of illuminated chromatic objects (e.g. colourful items as well as pale surfaces) is relevant. In addition, typical errors in glare assessment should be defined by ensuring overexposed values are detected and considered in the evaluation. Encouraging a more rigorous approach to camera calibration including an HDR-mode will impact other areas such as optical inspection (e.g. machine vision) and other optical measurement (e.g. dimensional measurement with vision systems where edge detection is an issue showing dependence on the level of illumination).

Everyday cameras (e.g. as those in smartphones) offer an HDR-mode by means of integrated post-processing. The proprietary algorithms align and combine images captured adjacent to another by means of registration of features (e.g. using autocorrelation). However, the algorithms are dedicated to reducing the noise in dim areas of a photograph, which includes several other corrections (e.g. stabilisation, white balance, gamma curve, etc.) and thus cannot be considered as a luminance measurement. Moreover, post-processing to obtain luminance images of high dynamic contrast by an ILMD is applied in the device firmware or by external software products, which typically include proprietary algorithms or lack documentation for the algorithms and parameters that are used to generate the HDR image, without overexposed pixel values and reduced stray light and noise. Undocumented algorithms hinder the proper modelling of the post-processing and the

determination of sensitivities for propagating distributions of input quantities to an uncertainty estimate. Therefore, a clear metric for using HDR-mode in luminance imaging is required along with post-processing algorithms to ensure the reliability of the results and discourage manufacturers from implementing “black box” solutions in the creation of HDR images.

Imaging devices based on a microelectronic pixel matrix sensor are a key enabling technology for developing powerful tools. By combining successive measurements of a scene obtained with different integration times, each pixel can cover an extremely broad dynamic range. As this sensor type is based on CCD- or CMOS technology, it utilises a charge accumulation mode but a single sensor reading has a limited dynamic range and linearity, which leads to significant but necessary corrections throughout the post-processing of HDR images. Existing CIE technical report CIE 237:2020 “*Non-Linearity of Optical Detector Systems*” do not deal with fundamental aspects that come into focus when considering HDR mode for imaging systems realised by post-processing of image sequences. In order to ensure traceability of high dynamic contrast luminance images in field measurements, strategies for the evaluation and validation of uncertainties should be provided along with detailed guidelines on the estimation of uncertainty components.

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 the traceable measurement and characterisation of HDR imaging systems and to support the standardisation of luminance distribution measurement methods that are required for glare, light pollution, and other lighting assessments.

The specific objectives are:

1. To develop luminance standards with high dynamic contrast pattern (covering more than 3 orders of magnitude) in order to characterise the dynamic range and spectral mismatch for different types of commercial instruments that are available for luminance distribution measurements (e.g. ILMD, RGB matrix sensor cameras). This should be based on the recommendations stated in CIE 232:2019.
2. To validate HDR luminance measurements (including non-linearity, internal stray-light, and lens flare), taking into consideration evaluation methods that are based on machine learning (i.e. as implemented in smartphone cameras) and environmental sensitivities. To define the requirements for traceable instrumentation and to demonstrate the inter-comparability of HDR luminance measurements (in general and between different camera technologies), including the effect of its uncertainty on glare assessment.
3. To develop a harmonised metric (i.e. an algorithm) for (i) generating an HDR-luminance image from a sequence of multiple raw images and (ii) enabling traceability of relative images scaled to one or a few traceable spot measurements of the scene.
4. To develop guidelines on the determination of uncertainty budgets for HDR luminance imaging measurements of single pixels and integral values (e.g. evaluation region, illuminance) as well as glare evaluation, according to existing standards EN 17037:2019, EN 13201-2:2015 and EN 12464-1:2011. This should include recommendations on relevant quality indices and test methods.
5. To contribute to the standards development work of CIE TC3-56, CEN TC-169 and IEC TC-34 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 (e.g. manufacturers of RGB sensors and cameras), 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, 19NRM02 RevStdLED and 20NRM01 MetTLM and how their proposal will build on those. The proposers should also indicate how their proposal will be linked to the objectives of 20NRM01 MetTLM.

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 and instrument manufacturers.

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 the potential European Partnership on Metrology 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

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1] CIE identified this topic as one of their priorities. Details are available at: https://msu.euramet.org/current_calls/pre_norm_2021/documents/cie_priority_005.pdf

[2] CIE identified this topic as one of their priorities. Details are available at: https://msu.euramet.org/current_calls/pre_norm_2021/documents/cie_priority_007.pdf