EMRP Call 2012 – Open Excellence, Industry and SI Broader Scope

Selected Research Topic number: **SRT-i21**
Version: 1.0

Title: Multidimensional reflectometry for industry

Abstract

The visual appearance of a product can be a key element for industrial competiveness. The characterisation of modern materials, which have strong angular dependent reflection behaviour and show a changing visual impression depending on the direction of observation, requires measurements that can only be obtained by multidimensional reflectometry. The JRP should set up and fully characterise the required measurement capabilities, identify relevant calibration geometries, build dedicated transfer standard artefacts and implement mathematical tools and models, in order to understand and utilise the connections between the microscopic structural properties of the materials, the macroscopic optical properties of the surface and the visual appearance of the object.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP Outline 2008, section on “Grand Challenges” related to Industry & Fundamental Metrology on page 12.

Keywords

Reflectance, transmittance, fluorescence, appearance, colour, gloss, texture, angle-dependence, multi-geometry, goniochromatic, sparkling, scattering, mathematical modelling, Bidirectional Reflectance Distribution Function (BRDF)

Background to the Metrological Challenges

The visual appearance of products and packing is often a decisive parameter in the judgement process of a customer. The fresher, brighter, glossier etc. a product looks, the more a customer is willing to buy it. However, this requires a production process, e.g. printing, painting, varnishing, which is reproducible and easy to supervise by quality control systems. At present, there are neither any standardised and traceable measurement procedures for quality control in this field nor are there existing standards which are used in the industry for traceability. If measurement setups, measurement procedures and “appearance” standards were available, higher reliability and cost reduction in production and quality control would be achieved.

The look and the optical functionality of a product surface is determined by the interaction between the incoming light, the structural and texture properties of the surface and finally the visual system of an observer. The measurement of the visual appearance of surfaces like this requires the knowledge of the structure, its interaction with the incoming light, and the possibility to measure the optical properties with at least the same acuity as a human observer. How the human visual system uses the part of reflected light that comes in the eyes to construct the visual attributes that provide the visual appearance is not clearly understood, but is required to identify optical measurands that are really seen and used by the observers.

Present measurements in the classical fields of reflectometry and spectrometry deal with the characterisation of standard reflection and transmission materials, such as opal glasses, barium sulphate pellets, ceramic tiles or neutral density filters typically with a traceability in standardised geometrical configurations. Such standardised configurations are the recommended geometries of the CIE, like d:0 (diffuse irradiation and detection under 0°) and 45:0 (directional irradiation under 45° with subsequent detection under 0°). However, it was shown that even for so-called cooperative standard materials, the reflection behaviour is not only wavelength dependent but also varies strongly with the geometry. This is the reason why new commercial instruments, so-called multi-angle spectrophotometer, entering the market. In a recent verification of the spectral radiance factor extreme deviations of up to 385 % were observed. This effect might be even more

dramatic for more complex standards which have specific features concerning angle and wavelength dependence. Consequently, there are enormous needs in industry for traceability of reflection and transmission measurements in multi-geometrical configurations.

Scientific and Technological 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 JRP-Protocol.

The JRP shall focus on the traceable measurement of optical surfaces and the definition of an irreducible set of measurements for different types of surfaces with strong angular dependent reflection behaviour.

The specific objectives are

1. To develop measurement methods for colour, gloss, texture, translucency, and fluorescence that allow the optical properties of functional surfaces to be measured in multi-geometrical configuration in the visible and close-by spectral ranges with high spectral and spatial resolution.
2. To develop new transfer standards for physical measurements of visual appearance including near-field/far-field conversion using imaging-based photometry.
3. To identify the minimum set of calibration schemes needed for the characterisation of different types of functional surfaces.
4. To determine the structural properties of the surfaces used in the development of these methods in order to model the relation between the optical properties and the three-dimensional structures of the surfaces.
5. To develop models for the determination of the various appearance measurands which allow the associated uncertainty to be determined.

The types of surface under investigation must be carefully prioritised along documented industrial needs and economic impact.

Proposers shall give priority to work that meets documented industrial needs and include measures to support transfer into industry by cooperation and by standardisation. An active involvement of industrial stakeholders is expected in order to align the project with their needs.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this.

The total eligible cost of any proposal received for this SRT is expected to be around the 2.7 M€ guideline for proposals in this call. The available budget for integral Research Excellence Grants is 42 months of effort.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community. This may be through the inclusion of unfunded JRP partners or collaborators, or by including links to industrial/policy advisory committees, standards committees or other bodies. Evidence of support from the “end user” community (eg letters of support) is encouraged.

You should detail how your JRP results are going to:

- feed into the development of urgent documentary standards through appropriate standards bodies
- transfer knowledge to the automotive, chemical, optical, printing and cosmetics sectors.

You should detail other impacts of your proposed JRP as detailed in the document “Guide 4: Writing a Joint Research Project”

You should also detail how your approach to realising the objectives will further the aim of the EMRP to develop a coherent approach at the European level in the field of metrology and includes 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 Member States and countries associated with the Seventh Framework Programme whose metrology programmes are at an early stage of development to be increased
- outside researchers & research organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.