Publishable Summary for 16NRM08 BiRD
Bidirectional reflectance definitions

Overview

The commercial success of a product is often dependent on its aesthetic appearance. For this reason, different industrial sectors e.g. automotive coatings, cosmetics, printed materials, are continuously looking to develop new attractive visual effects. This project focuses on the pre-normative work required to clarify how measurements on standard materials and surfaces exhibiting goniochromatism, gloss and sparkle visual effects should be carried out. This will enable a reliable comparison of results provided by different measurement devices and better control of the visual effects of products.

Need

Objects are identified through their shape, size and "visual attributes" i.e. colour, gloss, translucency and texture. These attributes define the appearance of the objects. For industrial manufacturers, the appearance of a product is important at the quality control level (because the visual appearance informs the manufacturer on the constancy and reproducibility of its production) and at the commercial level (because the appearance of a product directly influences the customer and the purchase decision). Within the last 20 years, substantial effort has been undertaken by industrial manufacturers to create attractive and sophisticated visual effects. However, current standards on colour measurement (ISO 11664) and gloss measurement (ISO 2813) are not adapted to the characterisation of sophisticated visual effects and no standard exists for Bidirectional Reflectance Distribution Function (BRDF) or sparkle. CIE (Commission Internationale de l´Éclairage) has currently initiated work on BRDF through TC2-85. Following on from the need to characterise visual effects and the absence of standardisation and standard methods in this field, manufacturers of spectrophotometer systems and NMIs are developing their own instruments, using different optical parameters and methods of measurement. This leads to a lack of comparability in the BRDF, gloss and visual texture; three aspects which determine the appearance of a product.

Objectives

The scientific and technical objectives of this project are to:

1. Propose standard parameters for the measurement of the BRDF of particular materials and optical surfaces in the visible range in order to improve the traceability to the SI between users and NMIs, and therefore to allow for better agreement between commercial goniospectrophotometers. The focus will be on i) settings of solid angles, ii) illuminated and measured areas, and iii) convergence of light beams. In addition, to provide guidance on how to sample the BRDF space efficiently and to propose a minimum number of measurement geometries according to the appearance properties of the specimen.
2. Propose arrangements for data handling and processing for BRDF measurements when a large amount of data is obtained.
3. Propose a new method for gloss measurement that correlates with visual perception. The contribution will be based on i) reflectance measurements, ii) visual evaluations and iii) definition of a standard gloss observer.
4. Propose a consensual definition of sparkle and graininess measurands and define procedures for their measurement in correlation with visual scales for sparkle and graininess.

5. Facilitate the uptake of the technology and guidance developed in the project by the measurement supply chain, e.g. instrument manufacturers and end-users, e.g. automotive, cosmetics, pigments, packaging and 3D printing industries. In addition, contribute to the standards development work of international standardisation bodies, e.g. CIE. Dissemination of project results will take place as early as possible to establish a standardised approach.

Progress beyond the state of the art

A significant metrological effort on BRDF measurements has been made over recent years, particularly at the European level due to the EMRP project IND52 xDReflect. That project enabled substantial progress in the field by:

- Raising the comprehension of the BRDF as a physical quantity,
- Improving primary measurement capabilities for BRDF measurement,
- Increasing the understanding of the link between BRDF and the visual attributes of materials like colour, gloss, sparkle and graininess,
- Proposing standard procedures and developing artefacts for the characterisation of visual appearance attributes.

This project will progress beyond the state of the art by:

- Initiating standardisation work on BRDF measurements and providing guidance on how to sample and to interpolate the BRDF space,
- Proposing a convenient method to arrange BRDF data which will facilitate communication between NMIs, instrument manufacturers and industry using BRDF data and will simplifies the usability of data bases,
- Developing definitions for sparkle and graininess measurands and correlating these well-defined quantities with visual experience using a psychophysical methodology,
- Establishing two new CIE technical committees to work on the standardisation of gloss and sparkle.

Results

Standard parameters for measuring BRDF

The project will mobilise the best facilities available in Europe, to test and validate the influence of all pertinent measurement settings, e.g. settings of solid angles, illuminated and measured areas, and convergence of light beams, on the BRDF measurement. These tests will be performed on each category of specific effect identified e.g. as quasi-lambertian, glossy, textured and goniochromatic effects. Guidance on BRDF measurement and how to sample the BRDF space will be made available to CIE TC2-85, as a first step to standardise BRDF measurements.

BRDF data handling and processing

In this project a universal BRDF data format will be developed by the partners by seeking input from diverse communities interested in acquisition, modelling and reproduction of material visual appearance, e.g. metrologists, spectrophotometer manufacturers, academics working on BRDF models, developers of virtual reality and video game applications, and end users from different industrial fields e.g. automotive, architecture, pulp and paper, and 3D printers. In addition, the most relevant appearance descriptors extracted from the raw BRDF data will be identified.

Gloss measurement and visual perception

A comprehensive collection of visual gloss scales will be gathered, and psychophysical studies will be performed as necessary to complement this collection of visual scales. The project will also gather and provide BRDF measurements of glossy samples. In addition, the project will propose to establish a CIE Technical Committee (TC) on gloss, with experts from CIE Division 1 and Division 2, together with industrial representatives.

Sparkle measurement and visual perception

Using a similar approach to that for gloss, the project will collect measurement data and visual scales for a large collection of sparkly samples and a CIE TC will be proposed with experts from different areas (metrology,

vision and industry). Proposals for sparkle and graininess measurands will be developed following discussion, led by the partners, with manufacturers and end-users. Psychophysical experiments will be performed to test the correlation between the quantities proposed and the visual perception. Finally, a procedure which will enable the measurement of sparkle will be proposed to the new CIE TC for sparkle and graininess.

Impact

Impact on industrial and other user communities

To promote the uptake of the outputs of this project by the industrial community, the partners will disseminate the results of this project through different routes. The recommendations will be made available to stakeholders and end-users from different industrial sectors e.g. instrument manufacturers, automotive, cosmetics, pulp and paper and printing industries. Presentations will be given at international conferences and meetings attended by industrial stakeholders and significant scientific achievements will be published in peer-reviewed papers and available to different communities. To ensure the relevance of the outputs to the industrial community, this project will establish a stakeholder committee with members from different sectors, including industry and seek feedback on the work being carried out.

The uptake of the outputs of this project by the industrial community will enable the development of novel instruments which will increase the competitiveness of European industries. The recommendations on the optical parameters for the measurement of BRDF will be crucial for instrument manufacturers to produce a new generation of spectrophotometers and to enable industrials to move from visual evaluation to objective BRDF measurement, leading to better control of the appearance of their products and less rejection by the customer. The consensual CIE standard observer for gloss will also facilitate the development of a new generation of instruments. This will allow a better control of gloss of materials with different nature or colour. In the long term, this is expected to have an economic impact for industries where the control of gloss is crucial. The uptake of adequate and trusted definitions of measurands and measurement procedures for sparkle and graininess that will be proposed in this project will enable the design and development of dedicated instruments, which will benefit in particular the automotive industry, where more than 90 % of car paint show a sparkle effect and where the need of a reliable and traceable measurement is urgent. The uptake of the recommendations for the characterisation of the full BRDF of goniochromatic visual effect pigments will support the production of multi-angle spectrophotometers and promote the confidence of end-users that the best geometries can be used to characterise the product.

Impact on the metrology and scientific communities

In the absence of standardisation, the primary facilities developed for measuring BRDF are made to be very versatile in order to satisfy particular customer requirements. In some cases this increases the measurement time and the measurement uncertainty. The take up of the technical recommendation on BRDF will enable NMIs to develop transfer reference facilities that could be based on commercial instruments developed by stakeholders of the project. Existing calibration services can be automated at the NMI and calibration laboratory level, resulting in a reduction of calibration costs and time, and improvement of the traceability.

The normative work carried on in this project will support the development of a new generation of spectrophotometers that will increase the need of calibration and traceability. As a result, the metrological community will have to and be able to develop new calibration services.

Sparkling is a challenging effect that presents a huge radiance dynamic in a very narrow angular angle. For measurement of sparkle and graininess, NMIs will have to integrate an Imaging Radiance Measuring Device (IRMD) in their goniospectrophotometers. This also requires improvement of the metrology for the characterisation of IRMDs that will be used not only for sparkle measurement but also for near-field radiometry and hyperspectral techniques and will trigger the development of NMI capabilities in this field.

Impact on relevant standards

This project will have a direct impact on different standardisation bodies working on new or improved standards, in particular CIE TC2-85, whose aim is to provide geometrical recommendations for the BRDF measurement according to the type of sample under investigation. The outputs of this project will be disseminated to this committee through a technical recommendation and presentations. Other standardisation bodies e.g. ISO TC35/SC14, ISO/TC 6 and CIPM – CCPR will also be briefed on the project's results at committee meetings. Another step towards the incorporation of the outputs of this project on standardisation is the creation of new CIE technical committees on gloss and sparkle, which will be provided with working

drafts on i) instrumental and visual evaluation of gloss, and on ii) the most appropriate definitions of sparkle and graininess measurands and procedures for their measurement, respectively.

List of publications

There are no publications at this early stage of the project.

Project start date and duration:	1 May 2017, 36 months	
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