European Metrology Research Programme

Delivering Impact

# Improving the measurement of gloss

Europe is the third largest exporter of products in the world. Many of these are high-value goods where product quality is an important purchasing factor. The human perception of quality however is a 'blend' of conscious and subconscious cues, spanning a range of parameters. Improving the link between traceable measurements and perceived quality would better support Europe in a wide range of industries.

**Europe's National Measurement Institutes working together**

The European Metrology Programme for Innovation and Research (EMPIR) has been developed as part of Horizon 2020, the EU Framework Programme for Research and Innovation. EMPIR funding is drawn from 28 participating EURAMET member states to support collaborative research between Measurement Institutes, academia and industry both within and outside Europe to address key metrology challenges and ensure that measurement science meets the future.

# Challenge

The EU accounts for around 15 % of the world's international trade in goods. Purchases are heavily influenced by conscious and subconscious visual cues which we relate as 'quality' in a product. A poor finish on a car, for example, may cause paint to develop an 'orange peel' look, eliciting a negative response in a buyer. This perception is important in a wide range of sectors that need to control all parameters related to visual quality, including automotive, paint, textile, construction, and aerospace industries.

Gloss, an important attribute, is measured by specular gloss meters. These illuminate a sample at specific angles and capture and record the light that is reflected off at the mirror angle with photodetectors. Although accurate, only one parameter of what humans perceive as gloss is captured - meaning two gloss surfaces measured can give identical results but appear very different visually.

Perception of gloss also depends on the 'diffuse' light emanating from the surface, the distinctness of a reflected image (DOI), and 'haziness' caused by scratches or swirls. It also includes contrast gloss (the difference between the highlight and its surroundings), the presence of different surface glosses, and imperfections.

Except for contrast gloss, industrial instruments exist to measure each of these characteristics. However, as no one instrument can measure all aspects, manufacturers spend considerable resources performing multiple measurements to ensure product consistency.

# Solution

During the EMPIR project BiRD, KU Leuven developed a prototype meter, termed i-GM, for the simultaneous measurement of multiple aspects of gloss perception. The optical layout was based on ISO 2813, which specifies a method for determining specular gloss using three angles of 20°, 60° or 85°, and the design was validated with the use of raytracing software. The photodiode detector was substituted with a colour CMOS camera, and a second a-specular LED light source added to allow extraction of surface details.

The prototype was then assessed in measuring reference materials consisting of 16 matte to high-gloss samples, in comparison to a standard meter, confirming the suitability of the system to perform standard specular gloss measurements. The resultant instrument was capable of evaluating each of the five main attributes of surface gloss: specular gloss, DOI, haze, contrast and surface-uniformity gloss.

# Impact

At the end of the BiRD project, the new i-GM instrument was further adapted in conjunction with project partner Rhopoint Instruments Ltd – experts in visual measurement systems and services.

A second CMOS camera was added to capture surface light, and the theoretical design of the system optimised via simulations. Image quality was improved by the addition of a lens diaphragm along with multiple LEDs to illuminate a sample from various angles.

The new meter, in addition to specular gloss, can measure a large range of parameters, including 'sparkle' and contrast gloss – the latter of which has never been incorporated before in a commercial instrument. As images are captured by cameras, physical texture can be extracted from the 3D tomography of a product's surface – including "orange peel" and other defects.

Rhopoint acknowledge the help of the project in the development of this instrument, based on sound metrology principles. This included the access to psychometric tests and simulations by the project's consortium, that helped link measurements to human perception of a product's appearance.

The development of such instruments, like the i-GM, will simplify quality processes, reduce production costs and provide greater accuracy between traceable measurements and what we perceive as 'quality'.

## Developing a metrological format for visual attributes

The visual aspects of an object depend on the angle of observation or the direction or polarisation of the light. To capture this requires the use of a *Bidirectional Reflectance Distribution Function* (BRDF), for which no standards exist.

The BiRD project addressed this, creating a universal file format for BRDF definitions detailing all data required for measurements along with metadata allowing future reproducibility and machine-readability.

The colour management software BiRDview was developed, and psychometric tests performed to link human perception of gloss under diffuse and specular lighting.

An image-based detector was developed that allows multiple parameters to be measured for a material's visual properties like 'orange peel' or 'contrast gloss'.

Project work led to the creation of CIE TC2-85, dedicated to BRDF measurements and CIE JTC 12, dedicated to sparkle measurement.

These results will allow improvements in a range of areas, from measuring the reflectiveness of roads and pavements to reduced costs in all areas where product appearance is important.

EMPIR EURAMET

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