On Practical Sampling of Bidirectional Reflectance

Accurate material models are a key part in producing convincing, photo-realistic, images in computer graphics. Elaborate analytical models exist, allowing graphics designers to manually design material appearance. However, given the complex nature and wide variability of material appearance, measuring this from the real world is an impractical and time-consuming process. Having a practical way of measuring material appearance will not only be of great value to the graphics community, but also open up for a wide range of new application areas, including industrial production quality control, digital prototyping and manufacturing, and interactive real-time product visualization.

In this thesis, the challenge of making material appearance measurements practical is addressed. Specifically, the Bidirectional Reflectance Distribution Function (BRDF), which is the quantity describing material appearance, is thoroughly analysed using both optimisation tools and multivariate statistics, in search of making BRDFs more accessible.

The work demonstrated includes an insight into the challenges of fitting analytical models to measured data and on the compromises one is bound to make when simplifying the real world with a parametric BRDF model. Specifically we identify what error measures work well for obtaining perceptually good results and how a simple BRDF model may be modified to better match real world data. With an offset in this, a linear, data-driven, BRDF model is proposed and a framework for reconstructing full and accurate BRDFs from only a few measurements is presented. It is here demonstrated that with as little as 20 point-samples, a BRDF can accurately be reconstructed. Furthermore utilising the field of view of a camera, this may be reduced to as little as two images. With this, the thesis demonstrates how BRDF measurements can be made practical, and it exemplifies this with a range of datasets intended for various purposes, each including high quality measured BRDFs.

Where the classical approach to BRDF capture may take weeks in measurement time, we here successfully demonstrate that is can in fact be reduced to no more than minutes or even seconds using our framework.