Material Appearance Prediction

Predicting and controlling the appearance of a material is of immense interest in different fields, from manufacturing to product visualization. Predictive rendering models are useful for designing and prototyping, and they can also be used for quality control in manufacturing. However, when an object is manufactured it often presents some deviations in appearance compared to the ideal model due to the manufacturing process. And it is not trivial to include these deviations in the predictive model. Being able to model the reflectance properties of a surface and then reproduce them on a physical object is also a hot topic in manufacturing. Unfortunately, this is often done by adding post-processing steps to the production pipeline and therefore adding extra costs and time to an already slow and expensive process. In this thesis, we address these challenges by proposing new techniques for appearance printing and predictive rendering. Specifically, our appearance printing techniques for 3D printing do not require any post-processing and can be directly implemented. And our predictive rendering models are derived for specific manufacturing techniques.

Our goal is to exploit the synergy between Computer Graphics and 3D Printing to build new predictive models and appearance printing techniques. More specifically, we contribute with two appearance printing techniques: the first one takes into account the limitations of color 3D printing and builds a predictive rendering model to overcome such barriers. The second technique, instead, makes use of grayscale images to obtain sub-voxel resolution in DLP 3D printing to print arbitrary micro-structure. On top of these, we propose an analytical model to predict the appearance and contrast of engineered surfaces and to perform quality inspection of such surfaces. We also describe a simple approach to quantitatively compare rendered images with photographs of 3D printed objects that can be used to build predictive rendering models.

With these contributions, we demonstrate the advantages of combining techniques from different fields, such as Computer Graphics and 3D Printing, to obtain better predictive models and appearance printing methods.
Modeling the Anisotropic Reflectance of a Surface with Microstructure Engineered to Obtain Visible Contrast after Rotation

Engineering of surface structure to obtain specific anisotropic reflectance properties has interesting applications in large scale production of plastic items. In recent work, surface structure has been engineered to obtain visible reflectance contrast when observing a surface before and after rotating it 90 degrees around its normal axis. We build an analytic anisotropic reflectance model based on the microstructure engineered to obtain such contrast. Using our model to render synthetic images, we predict the above mentioned contrasts and compare our predictions with the measurements reported in previous work. The benefit of an analytical model like the one we provide is its potential to be used in computer vision for estimating the quality of a surface sample. The quality of a sample is indicated by the resemblance of camera-based contrast measurements with contrasts predicted for an idealized surface structure. Our predictive model is also useful in optimization of the microstructure configuration, where the objective for example could be to maximize reflectance contrast.

Virtual reality inspection and painting with measured BRDFs

In this paper we present a color design pipeline for 3D printed or additively manufactured parts. We demonstrate how to characterize and calibrate a commercial printer and how to obtain its forward and backward color transformation models. We present results from our assistive color design tool, allowing for colorimetric accurate prints and visualization of the printed outcome, prior to print. Lastly, we demonstrate our pipeline by accurately reproducing a real physical object.