Graduate School on Digital Material Appearance

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Abstract

In this document, we introduce the graduate school on Digital Material Appearance which is part of the Institute of Computer Science II – Computer Graphics.

1 Introduction

The graduate school on Digital Material Appearance is part of the Institute of Computer Science II of the University of Bonn. Its goal is to advance the knowledge about digital representations of material appearance, including capturing, compressing, rendering and further processing of such data. This is an active field of research facilitating not only more realistic renderings than those produced using two-dimensional textures, but offering completely new applications in areas like quality control or cultural heritage. Currently, there are five Ph.D. students in the graduate school whose research projects will be presented in this paper.

At our group, we focus on an image-based representation of real-world materials, the *bidirectional texture function (BTF)* as introduced by Dana *et al.* [2], which is a six-dimensional function $\mathcal{B}(x, y, \theta_i, \phi_i, \theta_v, \phi_v)$, describing the reflectance depending on surface position (x, y), direction of incoming light (θ_i, ϕ_i) and viewing direction (θ_v, ϕ_v). Discrete approximations of this function are captured with our camera domes ([5], [6]), hemispherical gantries taking sets of images from different pairs of lighting and viewing directions. The most intuitive interpretation of a BTF matching this mode of acquisition is the notion of a "stack of two-dimensional textures", one for each combination of lighting and viewing angle.

2 Research Projects

Prior-enhanced BTF acquisition (D. den Brok). The brute-force acquisition of materials' BTFs is expensive in terms of setup costs and measurement and postprocessing times. However, many materials exhibit both similar surface structure and reflectance behaviour. My research is concerned with exploiting these similarities in order to improve the acquision process. To this end, I make use of a database of high-quality BTFs of 14 classes of materials with 12 specimen each, available at our group. As a first step, we demonstrated that, using a certain kind of linear models inferred from this database, it is possible to obtain fully resolved BTFs from angularly sparse measurements [4]. We expect that and shall investigate whether these models also lend themselves well to other scenarios, such as cheaper, low-quality acquisition setups.

Distance metrics for material appearance (R. Martín, J. Iseringhausen). An interesting open question is, given two material representations, how much different are they perceived? This could have applications in many fields. For example, if two representations *look* the same, why not choose the one that is cheaper in memory footprint or computing time needed. Even though material representations are generally quite high dimensional, humans optically perceive mainly a small number of parameters like color, gloss, roughness, shape, etc. This means appearance perception is a subjective process and independent of the representation. Perceptual reality is not the same as physical reality [1]. The goal of this project is to derive an appearance distance metric to measure the perceived difference of two material representations. For this, a psychophysical experiment must be performed. From the experiment a mathematical model will be inferred and analyzed.

Environment map acquisition with mobile devices (D. Seca). We are working on methods to acquire environment maps with handheld mobile devices to detect light sources in order to visualize materials' appearance on the mobile device. State-of-the-art methods for environment map acquisition involve working with expensive and special hardware. We propose using an Android mobile phone with camera and motion sensors. Our approach involves recovering High Dynamic Range images [3] as well as real-time updates of the environment map, in order to visualize the material appearance.

Spatial BTF extrapolation (H. C. Steinhausen). Many real-world materials exhibit surface structure vastly exceeding the sample sizes permitted by current BTF acquisition devices. This research project focuses on methods to extrapolate reflectance for unmeasured parts of a material sample from a measurement of a fraction of it, together with few images of the complete sample. In a first publication, we suggest the use of texture synthesis for this extrapolation [7]. Future research will focus on faster reconstruction methods and more compact representations which might facilitate on-demand extrapolation.

References

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