Photorealistic Rendering for Augmented Reality: A Global Illumination and BRDF Solution

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Figure 1: Virtual objects being coherently inserted into a real scene. From left to right, a porcelain vase with consistent illumination, a chrome teapot reflecting surrounding real objects, a glass bust refracting real objects behind it, and a car model exhibiting various materials.

Abstract
This paper presents a solution for the photorealistic rendering of synthetic objects into dynamic real scenes, in Augmented Reality applications. In order to achieve this goal, an Image Based Lighting approach is used, where environment maps with different levels of glossiness are generated for each virtual object in the scene at every frame. Due to this, illumination effects, such as color bleeding and specular reflections, can be simulated for virtual objects in a consistent way. A unifying sampling method for the spherical harmonics transformation pass is also used. It is independent of map format and does not need to apply different weights for each sample. The developed technique is combined with an extended version of Lafortune Spatial BRDF, featuring Fresnel effect and an innovative tangent rotation parameterization. The solution is evaluated in various Augmented Reality case studies, where other features like shadowing and lens effects are also exploited.

Index Terms: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, Augmented, and Virtual Realities; I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Color, Shading, Shadowing, and Texture

1 Introduction

Realism is a desired feature in any Computer Graphics application. According to Ferwerda [12], three types of realism may be considered in Computer Graphics: physical realism, where the aspect and behavior of the elements of a scene are precise with respect to the laws of Physics; photorealism, where the scene is visually compelling, although not necessarily correct in terms of Physics; and functional realism, where the main concern is providing useful information about the task represented by the scene. In the Augmented Reality (AR) domain, while functional realism is more suitable to some systems, such as industrial ones [16], many application domains take profit from photorealism. Two examples are interior design [14] and advertising [4].

Illumination is one of the key aspects that require careful consideration by photorealistic AR. There are two approaches for handling scene illumination: local, where spotlights, directional or point light sources are used; and global, where environment maps are used. Global methods are usually more complex than local ones, but they can handle indirect illumination, therefore generating more realistic results. Another important factor in photorealistic AR is the surface reflectance modeling. Bidirectional Reflectance Distribution Functions (BRDFs) [32] are often used to perform this task, since some of them allow the modeling of several objects made from different materials in a very realistic manner.

This paper contributes investigating Computer Graphics techniques that are suitable to solve the photorealistic AR problem. These techniques are placed together in an all-in-one solution in order to achieve seamlessly insertion of virtual objects. Some extensions to the adopted Image Based Lighting (IBL) and BRDF approaches are also proposed. King’s IBL [23] was adopted and extended to generate two additional levels of blurred environment map. These are later used by the BRDF in order to render materials that exhibit glossy appearance. It is worth reminding that, differently from McAllister [27], every environment map here is blurred on the fly. This last feature is what support dynamic specular and diffuse (light bleeding) reflections. The utilization of a different map sampling scheme for the spherical harmonics transformation is also proposed. It has the advantages of being both simpler and more general. In addition, instead of using a simple Lambertian BRDF, the Lafortune Spatial BRDF (SBRDF) [27] was chosen. This SBRDF was extended to support tangent rotation parameterization and the Fresnel effect. Although McAllister results suggest support to tangent rotation, the lack details motivated a custom solution proposed in this paper. Figure 1 exhibits some of the obtained results.

This paper is organized as follows. Section 2 presents some previous work about the topics hereby mentioned and explains how the contributions of this work are related to them. Section 3 de-

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