Real-time photo-realistic augmented reality for interior design

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Introduction

The aim of the ARIS (Augmented Reality Image Synthesis) project is the real-time photo-realistic augmentation of a photographic image with synthetic computer generated objects. The driving application for this development is interior design where a user wishes to interactively view and manipulate new items of furniture in the context of the room for which they are intended, checking for fit and aesthetics. The techniques that are being developed could easily be applied to many other scenarios.

Novel rendering techniques have been developed which allow for the realistic illumination of synthetic objects, accounting for both hard and soft shadows, and the compositing of these into a photographic image at interactive rates on commodity hardware.

Environment capture

To provide correct occlusion for the synthetic objects a geometric reconstruction of the scene is constructed. This is performed with the ICARUS[1] system which allows interactive reconstruction of a geometric model from a single image.

A light-probe and high-dynamic range (HDR) image are used to capture the lighting environment in the scene[2]. A calibration target present in both the HDR image and the image used to build the geometric reconstruction allows the light-probe to be located in the scene. Illumination information present in the HDR image is projected onto a geometric mesh generated from the reconstructed model. Individual mesh elements act as discrete light sources to shade and shadow the synthetic objects.

Rendering

An irradiance volume[3] of the scene is built as a pre-process and sampled at each frame to provide diffuse shading for the synthetic objects. Dynamically generated environment maps are used to simulate specular reflectance.

Efficient data structures have been developed to rapidly identify those mesh elements in the scene which illuminate the synthetic objects and to compute where these cast shadows. A single hard-edged shadow for each source of illumination is rendered and these are blended together to approximate the real shadow. Image fidelity can be traded against performance by varying the number of illumination sources considered.

The shaded synthetic objects and shadows are first depth-composited with the geometric model to generate occlusions, and then composited with the original photograph to produce the final image. Although these rendering techniques are approximations we have found them to be sufficient to generate believable representations (see figures 1 and 2).

The rendering algorithms have been incorporated into an ActiveX control thus allowing the system to be embedded within a web page for potential use in e-commerce applications (see figure 3).

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A client-server architecture has been developed to support multiple participants viewing and interacting with the system simultaneously – for example, to allow a remotely located interior design consultant to make comments and suggestions.

Techniques to simplify the environment capture process are being considered. Stereo correspondence could be used to automate the reconstruction of the geometric model if suitable images of the scene were available. We are also investigating the accuracy of building the HDR image from a library of pre-defined camera response functions, together with a single deliberately under-exposed image, of the light-probe since this will capture the perceptually important sources of illumination for shadow casting.

Fig. 1: Interactive shading and shadowing of a 2,500 triangle synthetic object into a background photograph at over 11 frames-per-second on an NVIDIA GeForce4 (left). For comparison, a ray-traced image is also shown rendered in 2 hours using existing differential rendering algorithms (right).

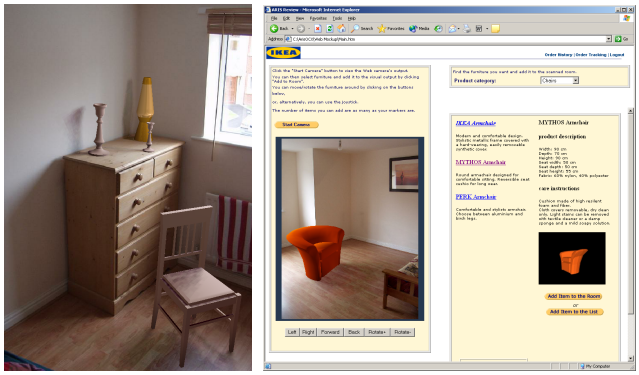

Fig. 2 (left): Multiple synthetic objects (chair, candlesticks, lamp)
Fig. 3 (right): The system integrated into a web page.

References

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