(5) The Importance of Shadows in Augmented Reality

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Abstract

Visual perception in the real, physical world relies heavily on cast shadows for interpretation of the spatial relationships between objects. I.e., shadows cast by objects onto other objects/surfaces is an important perception cue for understanding the 3D structure of the world, alongside with stereo disparities, size relationships, texture, and shading. In fact, recent experiments have shown that information from shadows can overrule information from stereo disparities and size relationships.

In Augmented Reality (AR) virtual objects are visually integrated with the real world to create the illusion of the virtual objects being a part of the real scene. But in light of the above statements concerning the importance of shadows it is clear that believability of, and the user's ability to spatially interpret, an AR scenario depends on functionality for enabling the augmented virtual objects to cast shadows on surfaces in the real world. Similarly, the virtual objects should have shadows cast on them from real world objects. And the virtual shadows should be consistent with the real shadows, for example in terms of lighting direction causing the cast shadows.

In order to be able to augment a real scene with both objects and shadows it is necessary to have a model of the lighting conditions in the real scene, and this model must be suitable for real-time computer graphics rendering. The work presented in this paper addresses this problem.

Our work is based on imaging the entire real scene from a central location, resulting in an omni-directional image, i.e. a panoramic image covering the full 360 by 180 degree field-of-view of the scene. This panoramic image is then used as a basis for estimating the directions and radiant power (color and intensity) of some limited number of light sources. These estimated light sources are then used in the real-time computer graphics rendering of virtual objects, such that virtual object shading and cast shadows are consistent with the lighting conditions in the real scene.

We have tested our technique with good results on various scenarios: a glass green house in a botanical garden with lighting conditions dominated by the sun and the greenish reflections from plants; an indoor hall with lighting dominated by three large windows; and a laboratory scene with multiple overhead light fixtures.