Title
Image Based Rendering and Illumination Using Spherical Mosaics

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INTRODUCTION

Rather than rendering using geometric primitives, image-based rendering techniques synthesize novel views directly from a collection of sample images. This approach has proven to be a powerful alternative to traditional geometry-based methods, making it possible to interactively render views of complex scenes.

The work described here extends the concentric mosaic representation developed by Shum and He [1] to spherical mosaics that allow the viewer greater freedom of movement. Additionally, by precomputing maps for diffuse and specular lighting terms, we use high dynamic range image data to compute realistic illumination for objects that can be interactively manipulated within the scene.

SPHERICAL MOSAICS

Concentric mosaics represent a scene using a series of sample images captured along a circular path looking outward. Spherical mosaics simply extend this approach by using a set of sample images that are taken from locations distributed over the surface of a sphere. Within an inner sphere, whose radius is determined by the sample camera's field of view, any exiting ray can be mapped to a location in one of the sample images.

The mapping is accomplished by intersecting the exiting ray with the capture sphere to determine the nearest sample cameras. A point along the ray at a constant depth is then projected back to the center of projection for each camera to determine the closest pixels within each image. Linear interpolation of the resulting values yields the value for the exiting ray. If depth estimates are available, they may be used to improve the accuracy of the projection into the sample images. Because the sample images form a four-dimensional representation of the external light field, the virtual camera is afforded a full six degrees of freedom within the inner sphere.

DIFFUSE AND SPECULAR MAPS

Once a scene has been sampled, adding additional objects into the environment requires realistically replicating environmental illumination when shading the new object. If the sample images have high dynamic range with pixel values that record incident radiance, then the illumination at any point within the inner sphere can be determined from the sampled data. Unfortunately, shading calculations at a point on the surface of the new object require expensive summations over all the incoming ray directions.

To achieve interactive rendering speeds, we move the summations to a preprocessing step and implement them by filtering the sampled data to form diffuse and specular maps. Both of these maps are stored as spherical mosaics. A mipmap-like structure holds multiple versions of the specular map computed with different sized kernels that can be used for different specular falloff parameters. The diffuse map is indexed according to surface position and normal, while the specular map is indexed by surface position and the reflected viewing direction. Simple ray-tracing provides a unified way to render both the spherical mosaic environment and the added objects.

RESULTS AND FUTURE WORK

We do not currently have a physical device for capturing spherical mosaics of real environments, so we have tested our methods using synthetic images generated using the RADIANCE rendering package [2]. The figures on this page (and the accompanying video) show images that were synthesized from a data set consisting of 9172 small (256×256) sample images acquired with a 90° field of view. The user is able to interactively change the view, add new objects, move the new objects, and modify their surface properties. A 256×256 anti-aliased image with exposure compensation can be re-synthesized in 1.05 seconds on an SGI 350 MHz R12000. Without anti-aliasing only 0.35 seconds are required.

The primary future extension of this work would be to build a physical capture device. Another area for further investigation is allowing the added objects to affect the environment lighting by casting shadows or creating reflections.

REFERENCES

[1] H.-Y. Shum and L.-W. He. Rendering with concentric mosaics. *SIGGRAPH 99*, pages 299–306, August 1999.

[2] G. Ward. The RADIANCE lighting simulation and rendering system. *SIGGRAPH 94*, pages 459–472, July 1994.

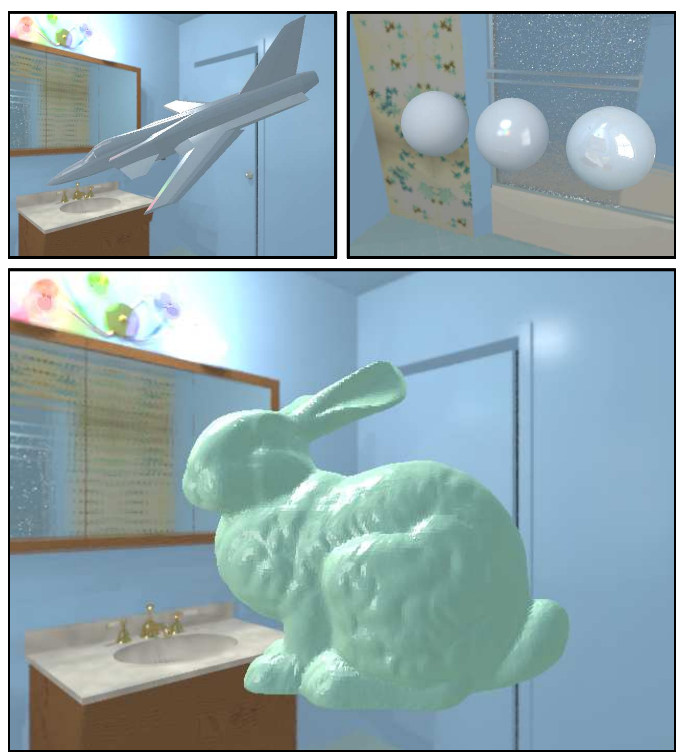

Image-based renderings showing inserted objects with different surface properties.