APPLICATIONS OF WORLD PROJECTIONS

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Abstract

Various techniques have been developed which employ projections of the world as seen from a particular viewpoint. [Blinn and Newell] introduced reflection mapping for simulating mirror reflections on curved surfaces and their method can be extended to simulate refraction. [Miller and Hoffman] have presented a general illumination model based on world projections. [Greene] has used projections of the world to model distant objects, and [Greene and Heckbert] have used world projections to produce pictures with the fisheye distortion required for Omnimax® frames. World projections can also be used as a backdrop for ray tracing or beam tracing.

This paper proposes a uniform framework for representing and utilizing world projections and argues that the best general purpose representation is the projection onto a cube. Surface shading and texture filtering issues related to environment mapping are discussed including approximate methods for obtaining diffuse and specular shading values from prefiltered environment maps. It is noted that obtaining accurate diffuse reflection and antialiasing specular reflection, which are both problematical with ray tracing, can be effectively handled by environment mapping.

Keywords: Environment mapping, reflection mapping, surface shading, texture mapping, cube projection, Mercator projection.

Omnimax is a registered trademark of Imax Corporation, Toronto, Canada.

1. INTRODUCTION

Reflection mapping, introduced by Blinn and Newell in 1976, is a shading technique that uses a projection of the world (a "reflection map") as seen from a particular viewpoint (the "world center") to make rendered surfaces appear to be reflecting their environment. The mirror reflection of the environment at a surface point is taken to be the point in the world projection corresponding to the direction of a ray from the eye as reflected by the surface. Consequently, reflections are geometrically accurate only if the surface point is at the world center or if the reflected object is greatly distant. The geometric distortion of reflections increases as the distance from the surface point to the world center increases and as the distance from the reflected object to the world center decreases. To apply reflection mapping to a particular object, the most satisfactory results are usually obtained by centering the world projection at the object center.

This method for approximating reflections can be extended to encompass refraction. Obtaining accurate results, however, requires much more computation since the ray from the eye should be "ray traced" through the refractive object, and in this process the ray usually splits into reflected and refracted components at surface intersections. As with reflections, results are only approximate for geometric reasons. (Note: Simply bending the ray at the surface point and using this as the direction of the refracted ray is not accurate, but may convey the impression of refraction.)

As Miller and Hoffman have described, the concept of reflection mapping may be thought of in more general terms as an illumination model. Essentially, they treat a world projection as an area light source which produces sharp reflections in smooth glossy objects and diffuse reflections in low gloss objects. This is a good model of illumination in the real world, although shadows are not explicitly handled and, as with reflection mapping, results are only approximate for geometric reasons. In order to speak generically of this approach and conventional reflection mapping, the term "environment mapping" will be applied in this paper to techniques for