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Trilinear Projection

by

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Abstract

In computer graphics a projection describes the mapping of scene geometry to the screen. While linear projections such as perspective and orthographic projection are common, increasing applications are being found for nonlinear projections, which do not necessarily map straight lines in the scene to straight lines on the screen. Nonlinear projections occur in reflections and refractions on curved surfaces, in art, and in visualisation.

This thesis presents a new nonlinear projection technique called a trilinear projection that is based on the trilinear interpolation of surface normals used in Phong shading. Trilinear projections can be combined to represent more complicated nonlinear projections.

Nonlinear projections have previously been implemented with ray tracing, where rays are generated by the nonlinear projections and traced into the scene. However for performance reasons, most current graphics software uses scanline rendering, where a scene point is imaged on a screen as a function of the projection parameters. The techniques developed in this thesis are of this nature.

This thesis presents several algorithms used in trilinear projection:

1. An algorithm to analytically determine which screen locations image a given scene point.

2. An algorithm that correctly connects projected vertices. Each scene point may be imaged multiple times, which means a projected scene triangle may form from one to four different shapes of from two to nine vertices. Once connected, the projected shapes may be rendered with standard scanline algorithms.

3. An algorithm to more accurately render the curved edges between projected vertices.

4. A scene-space edge-clipping algorithm that handles continuity issues for projected shapes across composite projections.

The trilinear projection technique is demonstrated in two different application areas: visualisation, and reflections and refractions. Specifically, various nonlinear projections that are congruent with pre-existing visualisation techniques are implemented with trilinear projections and a method for approximating the reflections and refractions on curved surfaces with trilinear projections is presented. Finally, the performance characteristics of the trilinear projection is explored over various parameter ranges and compared with a naive ray tracing approach.

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