HIDDEN LINE ALGORITHMS IN THREE DIMENSIONAL GRAPHING

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When rendering a three dimensional surface on a two dimensional screen, lines which cannot be seen by the viewer must be removed from the screen so that shape of the surface is not distorting by overlapping lines. In order to remove these lines, hidden line algorithms are applied in the surface rendering software to create a wireframe which contains only visible lines and hides the lines covered by the surface.

An algorithm which is often used is the one developed by Arthur Appel at IBM in the late 1960's. "This algorithm works by propagating the visibility from a segment with a known visibility to a segment whose visibility is yet to be determined" <http://en.wikipedia.org/wiki/hidden_line_removal>. By a comparison of the two following images, the line removal algorithm can be seen at work as the wireframe representation of the surface shaded object removes the lines which are not in view.

Although the ability of the algorithm to correctly remove hidden lines is clear, the way in which the algorithm removes these lines is hard to see. The basic algorithm is based on the principle stated by Walter Hedger in his paper on Vector Hidden Line Removal and Fractional Quantitative Invisibility.

"The topological silhouettes of a model are those edges that bound front-facing and back-facing regions of faces. Collectively, these edges are usually known as the silhouettes of a model with respect to a particular view vector. First the algorithm starts by projecting all of the edges into curves … classified as either back-facing, front-facing, or silhouettes … until the classification is unambiguous for each curve in its interior." <http://wheger.tripod.com/vhl/vhl.htm>

From this point, the three dimensional rendering of the function can be formed by using the quantitative invisibility (q.i.) which represents the number of faces which obscure a point. For Appel's algorithm a count of the number of obscuring front-facing faces (q.i.) on all the projected curves is used to implement hidden line removal.

Although much of the initial work in the field of hidden line removal was done by Arthur Appel, the field is still growing as there are exceptions when his algorithm is not effective. There exist a variety of other algorithms which are implemented in computer-assisted design (CAD) such as the object-precision algorithms of Weiss and Galimberti/Montenari and the image-precision algorithms Encarnacao (priority-edge intersection test and scan grid – point/surface test), Warnock, and Watkins. The most popular algorithms which are being used and enhanced are z-buffering and face

drawing algorithms like binary space partitioning. Z-buffering compares all the interior points of faces and therefore is much slower. Face drawing is faster since the hidden edges are overwritten, but computing the points in the interior of the face is time consuming. Furthermore, floating point computations are used to make a binary decisions which can cause problems when the decision is wrong <http://wheger.tripod.com/vhl/vhl.htm>.

Although programs are currently limited to utilizing algorithms with the least error, the development of the original algorithms of Arthur Appel has opened up a new field of vector hidden line removal as people begin to search for fast, effective, and error-free algorithm which can be used for hidden line removal.

References:

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