Shadow Polygon Reduction Techniques

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INTRODUCTION

Shadow volume algorithm was introduced by Frank Crow in 1977[1]. It allows concave polygons with holes and any number of light sources anywhere in 3D space in the scan-line process. But it is expensive for image synthesis on the complex environment, because it generates a lot of shadow polygons. This paper presents shadow polygon reduction techniques in order to relax the restrictions under polygonal database. The techniques are a use of co-plane surface data structure, shadowing polygon determination using space subdivision, and contour edge extraction. By using the techniques, shadow volume algorithm becomes effective on the complex environment.

DATA STRUCTURE AND ALGORITHM

Data Structure

In this paper, we assume that data model is a polygonal model, and each polygon has appropriately oriented.

Moreover, we propose the following data structure shown in Fig. 1. The co-plane surface, we called "seal", has the same plane equation, and it has each attribute information(color, reflection,.etc.). Shadow polygon is generated on only the outer edge of the surface and the edge of the hole.

Extraction of polygons casting the shadow

Bouknight and Kelley project the scene onto a sphere centered at the light source and use bounding box tests on the projected polygons in order to determine the self-shadows and the projected shadows for every polygon[2]. However, the technique makes it a little difficult to calculate whether polygons intersect. We therefore propose space subdivision into 6 quadrangular pyramids.

An imaginary cube is created at the center of a point light source, and we divide the cube into 6 quadrangular pyramids (Fig. 2a). We can define the size of the cube, which encloses all polygons in the scene. Each face of the cube becomes a virtual screen, on which polygons can be projected.

For a spotlight source, the cube does not need to be divided (Fig. 2b). We suppose that the spotlight is enclosed by a quadrangular pyramid. When the light is parallel, we place the virtual screen in a suitable position and project polygons onto it.

Each polygon in quadrangular pyramid is projected on the virtual screen, and the bounding box values (Xmin, Ymin, Xmax, Ymax) on the virtual screen are then calculated simultaneously. Background polygons for a point light source are eliminated. The following steps 1)-2) are processed on every pair of polygons in each quadrangular pyramid in order to extract the polygons casting the shadow.

step 1) Bounding Box test

Using the bounding box test, we eliminate unnecessary polygons, which do not cast shadows or which are themselves shadowed.

step 2) Calculation of depth

We check for intersections of the edge of all polygons that survive the bounding box test. If an edge intersects another, we must calculate the distance from eye-point, we call "depth", at the intersection point.

By calculating the depth at the intersection points, we find a pair of shadowing polygon and shadowed polygon.

If edge doesn't intersect, we do the inclusion check. When a polygon is included in other polygons, we calculate the depth at the center of the polygon that is included.

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Else, the polygon does not cast a shadow or is not itself shadowed.

Extraction of contour edge

Contour edge lies at the extremes of the surface for open polyhedrons. So, by checking the duplicate of edge on the extracted polygonal data, we extract the contour edges. When edges are not shared, the edges are contour edges.

By using the extracted contour edges, we generate shadow polygons. Shadow polygons are processed by the scan-line algorithm.

CONCLUSION

We described the shadow polygon reduction techniques in order to render the complex scene of polygonal database. Fig. 3 shows the output using the techniques.

REFERENCE

[1] Crow, F. C., "Shadow Algorithm for Computer Graphics," Siggraph 1977 Proceedings, Vol. 11, No.2, 1977.

[2] Bouknight, Jack, and Kelley, Karl C., "An Algorithm for Producing Half-tone Computer Graphics Presentations with Shadows and Movable Light Sources," AFIPS Press, Montvale, N.J. pp.1-10, SJCC 1970.

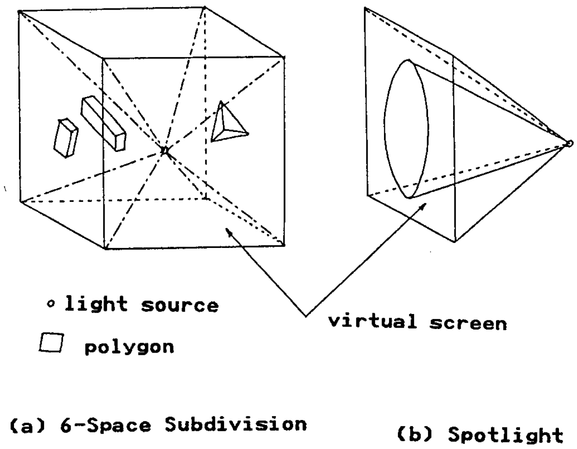

Fig. 2 Space Subdivision and Virtual Screen

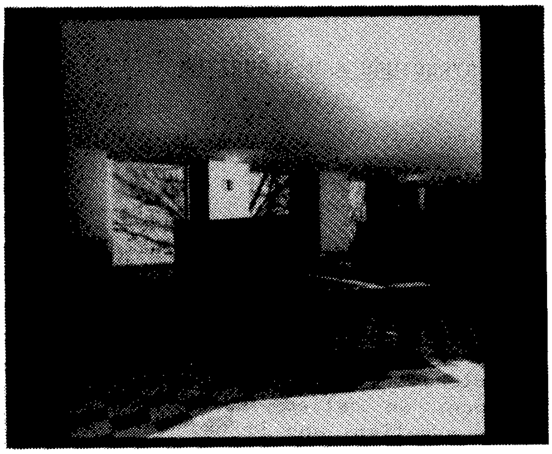

Fig.3 A room
A point light source is located in the center of the room.
No. of Polygons 1641
No. of Shadow Polygons 961

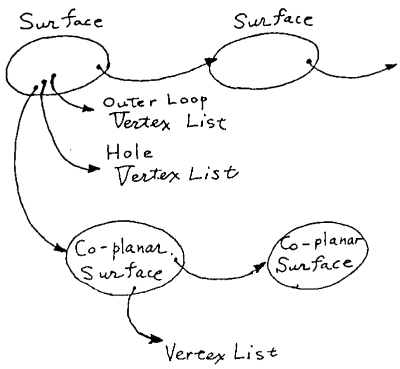

Fig. 1 Co-plane Surface Data Structure