REVIEW ON RENDERING RIGID SHADOWS USING HYBRID ALGORITHM

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ABSTRACT

We present a review on rendering rigid shadows precisely and proficiently. Our review provides the details of all the existing methods for rendering shadows and the hybrid approaches. Hybrid approaches merge the two or more existing algorithms. The algorithm merges shadow map and shadow volume computation. Analysis of shadow volume, shadow map and projection algorithm is performed and is mentioned in the paper along with the detail of important elements used for the implementation of the algorithm.

Keywords- buffer, mapping, projection, rendering, shadow, volume.

I. INTRODUCTION

Shadow maps and shadow volumes are two renowned means of rendering real-time shadows. Shadow maps are proficient and adaptable but they are prone to aliasing effect. Whereas shadow volumes are accurate, but they posses higher fill-rate requirements and so does not scale appropriate to complex scenes.

Shadows are widely used in presenting the objects reality. The usefulness of lance Williams original shadow algorithm [1] is self-evident as Pixar's RenderMan utilize this technique. The primary idea is apparently straightforward, yet its biggest profit is its greatest drawback which is the discrete nature of image space computation and hence the presence of aliasing artifacts.

Rather than shadow map, which works in image space, Crow's shadow volume algorithm[2] works in object space by creating polygons to present the boundary between illuminated and shadowed region. The shadow volume is the region covered by these polygons. A shadow query is used to verify whether a point resides with in the volume.

Sen et al. [3] noticed that shadow map aliasing is just recognizable at the discontinuities between shadowed and lit regions, i.e. at the shadow shapes, on other side; shadow volumes calculate shadows accurately at each pixel but this certainty is required only at silhouettes. This analysis takes us to another technique referred to as hybrid algorithm which makes use of a slower but definite algorithm near shadow discontinuities and uses less accurate but faster algorithm at other places.

II. THEORY

A differentiation can be created between Image and Object space algorithms.

2.1 Image Space

The presentation of graphics in form of Raster or rectangular pixels has become very popular. Raster Scan displays are very flexible as they refreshes the screen on the basis of the values stored in the frame buffer. Image space algorithms are very easy and accurate as they have the similar data structure as of the frame buffer. The most widely used image space method is Z-buffer algorithm which is used in graphics for storing the values of z co-ordinate of the displayed object.

Image-space algorithms are less proper but they also give lesser constraints on scene presentation. In process, regardless of the fact that scene is presented with polygons, they can be simpler to utilize and more flexible. For example, many applications make use of polygonal primitives but create them over the Y form other presentations. Fortunately, for some applications shadows don’t need to be exact to be helpful, and image accuracy algorithms can be utilized. Image space is implemented in screen co-ordinate system. It determines the pixel which is visible of the object.(Fig. 1)

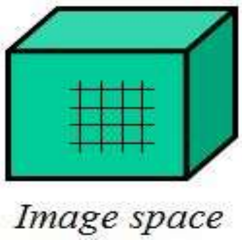

Fig. 1

2.2 Object Space

Object space algorithms provide the benefit of storing the important and related data and due to this ability the communication of the algorithm to the object is easy. The computation performed for the colour is carried only once. Object space algorithms also help shadow creation to increment the z-values of the 3D objects on screen. This algorithm is used in software methods as its implementation in hardware is difficult.

Object space provides more accurate shadows but in needs the accessibility to the polygonal presentation of the scene. Polygonal presentation are not present in the systems which make use of another modelling and rendering methods fro example selective raycasting of objects, distance volume primitives[4]. It is presented in physical co-ordinate system. It determines the object part which is visible. (Fig. 2).

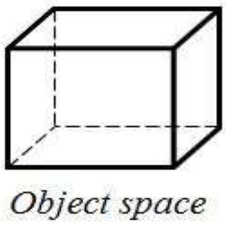

Fig. 2

2.3 Soft Shadows

Mainly soft shadows are very less definite and blur at the edges (Fig.3).

Fig.3 Representing Soft Shadows of the Object

2.4 Hard Shadows

Mainly shadows are hard which are defined crisply and have sharp edges(Fig. 4).

Fig. 4 Representing Hard Shadows of Object

III. SHADOW ALGORITHMS

Analysts have created multiple shadows algorithms over the years, few of them depends upon the classic shadow map and volume methods.

Present hard shadow techniques can be categorized in 4 categories:

1. Ray casting
2. Projection
3. Shadow Volumes
4. Shadow Maps.

From these techniques, last 3 are used for real-time rendering.

3.1 Projection Algorithm

This method projects primitives far from the light source on the surface of other primitives. Blinn's fake shadow algorithm[5] suppress all polygons of the object producing a shadow on the plane of other polygon. Here they can be shown in black or blended on the previously generated pixels to approximate the shadow of object on the plane. This method is basic and suits well for hardware acceleration but are not good to scale or generalize.

Normally object-space projection algorithms trim polygons into shadowed and unshadowed parts[6] in a prepass. As they works on polygon clipping, this method needs access to polygonal representation of scene.

3.2 Shadow Maps

Shadow maps were presented by Williams in 1978[1]. This algorithm performs its operation in image space. Initially it renders a depth map of scene from the direction of light, depth map is then used to analyse which samples of final image are obvious to light. Shadow maps are powerful and are backed by the graphics hardware, but they contain aliasing effect. Analysts have created many methods to address shadow map aliasing. Approaches which are based upon filtering and stochastic sampling[8] generated good antialiased shadows. As a matter of fact, this filtering requires a huge number of samples per pixel which is not only expensive as well as very crucial for real time applications. Self shadowing artifacts that are obtained from large filter width are totally scene dependent and are also hard to avoid. On the other hand there exist several methods to avoid aliasing by incrementing the shadow map resolution. Adaptive shadow maps [9] identifies and regenerates undersampled areas at higher resolution of the shadow map. Another technique used is Perspective Shadow map [10] which is much easier than others. The reason behind it is it uses an additional perspective transformation which gives the higher resolution in shadow map which resides near to the viewer. The above method is easier and works at higher speed but on other hand it does not eliminate the aliasing in every case. For example Fig.5 represents the shadows generated by using the shadow map algorithm. The image presents the aliased edges of the object which is cube in the example.

Fig.5 Representing Shadow Using Shadow Map Function

Shadow map algorithm utilizes two steps to generate shadow scene. The first step is used to generate the shadow map and the other one just applies it to scene.

The first step creates the scene from the viewpoint of light source. Perspective projection view is created if the light source is a point. Whereas orthographic projection is used if the source of light is directional such as of Sun. Depth buffer is created and stored by using this rendering method. As we know that the buffer values are important it can be chosen to neglect the updation of colour buffers and computations for lighting and textures. The buffer values stored are to be refreshed each and every time alterations are made to objects which are present in the scene.(Fig.6)

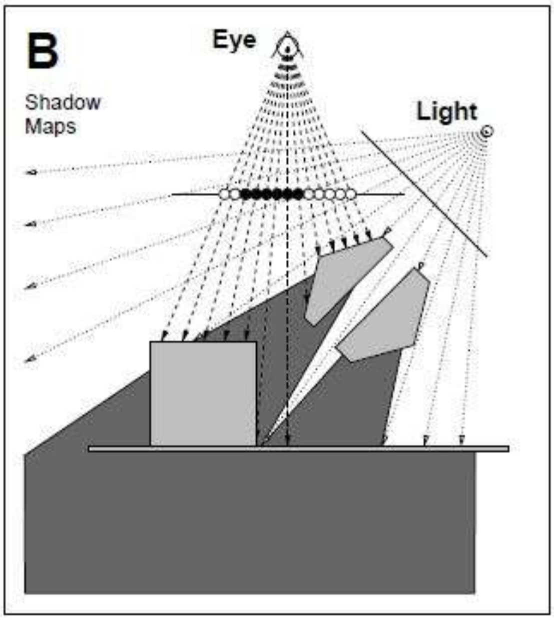

Fig.6 Shadow Map Technique

In many cases it is possible to generate shadows for only a particular set of objects in the scene in respect to shadow map so that the time taken to regenerate the map. Likewise a depth value shifter may be applied to shadow creation which is used to shift objects far from the light source in order to provide the solution for stitching problems which arises in the cases where the value of the depth map lies near to the surface map which is to be created.

In second step the task is to create the scene on the basis of usual camera point of view using the values of shadow map. This task makes use of three components from which the first one is to identify the coordinates of the object which is observed from the light source. Another component is the comparison which is performed upon the coordinates in contrast to the depth map. Final component is the construction or representation of the object in shadow or light.

Testing a point of object in respect of depth map requires its conversion must be done first from its relative position as in scene coordinates into the respective position as determined by ht light. This conversion process is carried out with the help of matrix multiplication. Coordinate transformation is mainly used to identify the object position on the screen but another coordinate set is also created in order to keep the location of objects in light space. The matrix we create here to compute the world coordinates provides a value set of homogeneous coordinates which require conversion to the normalized device coordinates. It has the components (x,y,z) lying in between to -1 and 1. An additional scale and bias matrix computation is being performed in implementations to convert the values from -1 to 1 into the required 0 to 1 values which are more regular coordinate values for the depth map.

3.3 Shadow Volumes

Virtual world of object representation is divide into two areas by the shadow volume as first, the area which lie in shadow and another which not. This method of shadow rendering has achieved the popularity in real time shadow generation as compared to the popular shadow mapping. Shadow volumes are used mainly because of their advantage of defining shadows accurate to the pixel. But, CPU intensive shadow geometry creation process is required by the shadow volume. Shadow volume computation utilizes large fill time and polygons are also huge in respect of utilizing screen space as compared to shadow maps which does not carry limitations like this.

Shadow volume algorithm proposed by Crow[2] perform its operation in object space where enlightened and shadowed regions are represented by making polygons. These polygons capture a certain area of object which is referred as shadow volume and the evaluation of point for its presence inside the shadow volume is carried out by executing a shadow query.

Another method to accelerate the computation of volume acquired by the shadow is proposed by Heidmann[11] who uses a hardware based stencil buffer to perform the operation of calculation. Unsuccessfully, number of robustness issues is present in the shadow volume algorithm musing stencil buffer. Also the algorithm proposed is unable to process the scenes which have high shadow complexity. Creating an extra geometry is involved in the process but the requirement of the large fill rate by the algorithm is the main problem. This failure is caused mainly due to 2 reasons. First reason is that heavy shadowed scenes which are mapped using shadow volume polygons are taking up the higher amount of screen surface. Whereas the second reason is that the updation in stencil buffer are made by every shadow polygon for every rasterized pixel as the polygons in the screen space overlap.

All the techniques defined above are very useful for determining the shadows of object but they become less effective as soon as we go for the cases having heavy shadow regions. The reason for this reduced effectiveness is that the computation of pixels which exist near to the shadow are specifically those which falls in depth ranges, so in his case the pixels are obtain no benefit for the optimization techniques used. Fig. 7 represents the shadow of the object created by using the shadow volume technique.

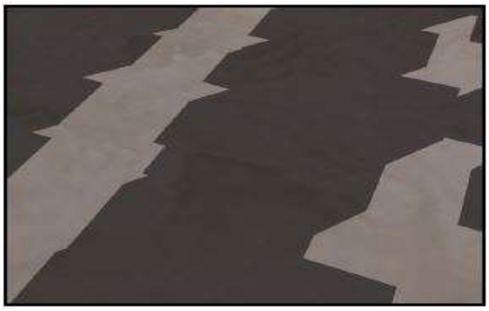

Fig.7

Lloyyd [12] provide another approach to compute the shadow volume which reduces the rasterization costs. The process taken by them involves the execution of query to use image space occlusions which are used for identification of blockers which are spread in the complete shadow, and the polygons created by using shadow volume are unnecessary and can be culled. Other than this Lloyd et. Al also gives a technique for shadow volume polygon in which screen space is made limited. This technique is performed in two ways. In first, the value computation of shadow receivers which are held by the depth differences obtained from the light source. In second, occlusion queries are applied to the disconnected slices obtained by the division of observer's view portion to resolve the selection of slice containing receivers. Lloyd provided a method which decreases the shadow volume polygons number and size which eventually reduces the fill rate.

For the generation of shadow volume , a ray is fired from the light source passing from every vertex to some point from the object which is shadow casted. Volume is generated by all these fired ray projections. The determination of shadows is then performed by identifying the objects lying inside and outside of the volume, inside point are referred as shadow whereas all the points outside the volume are light glow. In case of the modelling by polygon method volume of the object is mainly generated by differentiating between the faces by determining whether the face is in front of the light source or lies on the back of light source. Combination of the edges which combine the front face to the back face creates the silhouette in accordance to light source. Edges which collectively generate a silhouette are expelled away from light to generate faces of shadow volume. The volume so generated must cover up the complete visible scene. In order to create a closed volume front side and the back of this removal must be secured. On the basis of the method used to generate shadow volume the faces of the object in the set are dependent.

Problem also exists with shadows where silhouette edges become shallow along faces. For this situation shadow created by an object over itself will be sharp, showcasing its polygonal features, while the conventional model for lighting will have a progressive change in lighting. Due to this rough shadow artefact which lie around the silhouette edge are generated which are hard to be corrected. This problem can be minimized by incrementing the density of polygon but it will not permanently distinguish this problem.

Fig. 8 represents how shadow volumes are generated of the objects.

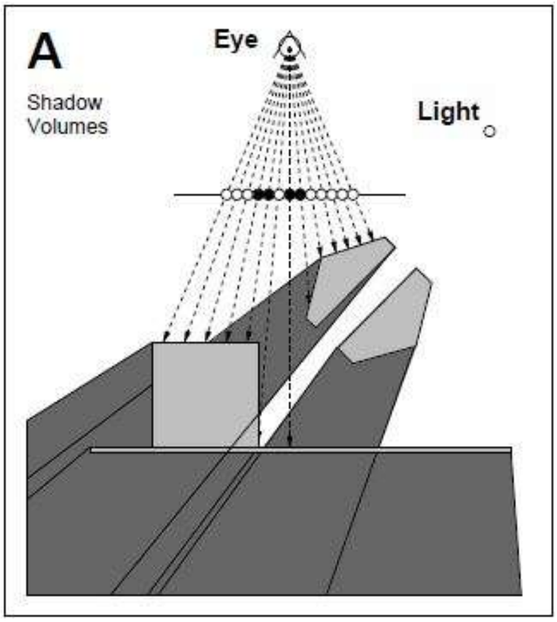

Fig.8 Shadow Volume Technique

Steps involved in generating shadow volumes are:

1. Search all the silhouette edge.
2. Expand all the found silhouette edge far from light source direction.
3. Generate closed volume by adding the front or back cap.

3.4 Stencil Buffer

Another buffer which is found in current graphics system along with colour and depth buffer is stencil buffer. It stores the integer value for every pixel utilizing one byte for every pixel. This buffer along with the depth buffer share same RAM area. Usually the stencil buffer is used for limiting the area acquired by rendering. Rendering pipeline makes use of the link between the stencil buffer and the z-buffer. Automatic increment or decrement for the stencil values assigned to every pixel can be done on the basis of the test for the pixel whether it passes or fails.

Tim Heidmann[11] showed the concept of using the stencil buffer to generate shadows using the shadow volume algorithm for use in real time applications fast enough to be considered. 3 different techniques are defined using this concept which are depth pass, depth fail and exclusive-or.

The process used by all these techniques is same as follows:

1. First generate the scene as it lies completely in the shadow.
2. For every light source present in the scene:

2.1 Make use of depth buffer to select the surfaces where visible surface does not lie in the shadow are and generates a mask which is in stencil buffer which contains holes at the visible surface areas.

2.2 Repeat the scene generation process again considering the scene being completely glow by applying the information in stencil buffer.

Second step of the process in which mask generation is performed creates a difference in the above three techniques. Some takes only two iterations and some may only one or some only needs less accuracy in stencil buffer.

3.5 Hybrid Algorithm

McCool [13] first defines the algorithm which uses the combination of shadow map and volumes referred as hybrid algorithm. The algorithm in first generates the depth map and then it executes and edge detection technique to search for the silhouette edges. Then the algorithm regenerates the shadow volumes using the edges determined and then makes use of them to calculate the shadows in the image obtained. The benefit of McCool algorithm is it only generates the polygons using shadow volume technique for silhouette edges that can be seen from the light source. But it has the problem of requirement to read the depth buffer again which is expensive and the polygons generated are completely rasterized. Also the aliasing effect can generate artifacts in shadow volume generation.

Another hybrid approach is proposed by the Govindaraju et al[14]. Their approach uses the technique of bounding the number of computation required in order to generate the precise shadow silhouette. Their approach minimizes the object processing performed by clipping algorithm. Their clipping algorithm uses the software method for performing the clipping of polygons.

IV. CONCLUSION

Review of the shadow rendering techniques is performed which provides the analysis that hybrid algorithms to render shadows of the object reduce the time taken in rendering the shadows. Hybrid algorithms combine two shadow rendering algorithms to create an efficient one. The use of hybrid algorithm is useful in game systems, graphic systems etc. to process shadow rendering faster.

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