Introduction

Shadow Mapping is a reliable technique to produce shadows in a scene in real time. This technique has been mostly applied to directional lights, and only a few methods have used it with omni-directional lighting. These methods need more than one full render pass to compute the whole shadow mapping. In this work, we propose an approach to achieve an omni-directional shadow map in a single pass.

Our method has three main advantages over previous related work:

- It is computationally efficient, since it provides omnidirectional shadow mapping at a similar speed as directional shadow mapping algorithms.
- The depth data of the triangles projected in this approach does not change with the position of the triangle, like in the Dual-Paraboloid method.
- The projection achieves the storage of the data in just one drawcall per triangle, instead of two drawcalls for the Cube Map and Dual-Paraboloid method.

Note that the Dual-Paraboloid can also be obtained in one pass, however, making this method cause distortion in the depth data near the boundaries of the paraboloids.

Sphere-Unfolding mapping

Our method projects the input geometry onto spherical triangles (triangles on the sphere), where the sphere is centered at the light source. We proceed by choosing two opposite poles of the sphere $y^+$ and $y^-$ and "unfolding" each arc connecting the poles in such a way that the unfolded arcs are connected by only $y$ (Fig. 1). We call this process sphere-unfolding and is defined by the projection:

$$\sigma(x, y, z) = \frac{\arcsin(y) + \pi/2 \sqrt{x^2 + z^2}}{\pi} (x, z)$$

There are basically two issues with this projection:

1) The spherical triangles that contain the $y^+$ pole, are inverted in the rasterization.

2) The projection is not linear.

To solve the first issue, we split the depth texture in such a way that half of the texture contains the unfolded sphere with respect to $y^+$ pole, and the other half contains the unfolded sphere with respect to $y^-$ pole. We call this process dual sphere-unfolding (Fig. 2).

For the second issue, note that the triangle deformation is negligible for reasonable-sized triangles.

Anti-Aliasing

For the aliasing in the shadow outline (Fig. 3) we introduce an antialiasing method that needs 2 passes:

For each pixel $P_{ij}$ in the Shadow Map let $\varepsilon$ be the discontinuity threshold.

Let $A_R = \{ |i - k| : |i - k| \leq R, |P_{i,j} - P_{k,j}| \geq \varepsilon \}$

Let $X_{i,j} = \begin{cases} \min(A_R) & \text{if } A_R \neq \emptyset \\
\infty & \text{otherwise.} \end{cases}$

Let $Z_{i,j} = \min_{|i-k| \leq R} \{ |j - h| + X_{i,k} \}$

This stores in $Z_i$ the nearest discontinuity, in Manhattan distance, to each pixel in a $R \times R$ region. Using this information is possible to dim the illumination of the pixels near to a shadowed pixel. This method is equal, in speed performance, to a separable gaussian filter of size $R \times R$.

Results

- The computational cost is slightly more expensive than directional Shadow Mapping.
- The projection also can be used to obtain environment maps.
- It is achievable in one pass with one texture.
- Very useful in closed scenes.

References


B. OSMAN, M. BUKOWSKI, C. M. 2006. Practical implementation of dual paraboloid shadow maps.