Dual Sphere-Unfolding Method for Single Pass Omni-directional Shadow Mapping.

Marcel Stockli Contreras, Alberto José Ramírez Valadez, Alejandro Jiménez Martínez *

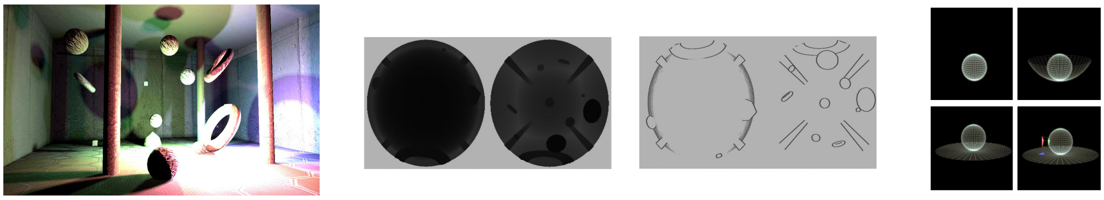

Figure 1: a) *Render of the scene,* **b)** *1024x1024 Shadow map,* **c)***1024x1024 Edge map,* **d)** *Sphere-Unfolding visualization.*

1 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 for omni-directional lighting [Brabec et al. 2002]. These methods need more than one full render pass to compute the whole shadow mapping. In this work we propose an approach to achieves 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 onmidirectional shadow mapping at a similar speed as directional shadow mapping algorithms.
- The depth data of the of the projected triangles does not change with the position of the triangle, like in the Dual-Paraboloid[1] method.
- The *projection* achieve the storage of the data in just one drawcall per triangle, instead of two drawcalls performed by the Cube Map and Dual-Paraboloid methods[2].

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

2 Our Work

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^+, y^-, and "unfold" each arc connecting the poles in such a way that the unfolded arcs are connected by only y^- (Fig. 1.d). We call this process *sphere-unfolding* and is defined by the projection $\sigma : R^3 \to R^2$ given by Eq. 1. Finally, we linearly render the depth value of the triangles in the depth texture.

*GameCoder Research/Universidad de Guanajuato/CIMAT, e-mails: {alberto,marcel,alexmar}@cimat.mx

[1]Wich expands the triangles near the boundary of the paraboloid, losing precision.

[2]It is necesary two drawcalls for those triangles that intersect the edges of the cube or the boundary of the paraboloid, for Cube Map and Dual-paraboloid method, respectively.

Note that there does not exist a linear homeomorphism between the plane and the sphere.

$$\sigma(x, y, z) = \frac{\arcsin(y) + \pi 0.5}{\pi\sqrt{x^2 + z^2}}(x, z) \tag{1}$$

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, meaning that the preimage of the shadow mapping of each triangle is a curved triangle.

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 the y^+ pole, and the other half contains the *unfolded* sphere with respect to y^- pole[3]. We call this process *dual sphere-unfolding*. Then we render each spherical triangle onto one half of the texture according to their nearest pole.

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

For the aliasing in the shadow outline we introduce an antialiasing method that needs 2 passess:

For each pixel $P_{i,j}$ in the Shadow Map let ϵ be the discontinuity threshold

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

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

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

This stores in $Z_{i,j}$ the nearest discontinuity, in Manhattan distance, to each pixel in a region of *R*x*R*. Using this information, it is posible to dim the illumination of the pixels that are relatively near to a shadowed pixel. This method is equal, in speed performance, to a separable gaussian filter of size *R*x*R*.

The projection also can be used to obtain environment maps.

References

BRABEC, S., ANNEN, T., AND SEIDEL. 2002. Shadow mapping for hemispherical and omnidirectional light sources. *In Computer Graphics International.*

[3]To keep the resolution of the depth texture we can expand the width of the depth texture by 2.