Summary of *Perspective Shadow Maps*

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Shadow mapping is the most widely used in real-time graphics applications for generating shadows, but it suffers from aliasing problems in certain situations. The paper introduces an approach that produces shadow maps in post-projection space instead of world space to solve the problem. The main idea is to transform the light into the post-projection (NDC) space.

There are previous works targeted at solving the shadow aliasing problems. Several approaches tried to filter the shadows to get a better look, but they didn't solve the undersampling problem itself. Other methods used multiple shadow maps with different resolutions, but they don't map to hardware. There is also an approach that introduced a hierarchical shadow map representation, but it is a software solution since it requires the traversal and refinement of a hierarchical data structure.

To do shadow mapping in NDC space, the light source itself should also be projection transformed. There are different cases during this step. According to its direction, a directional light source could be transformed into a point light, an inverted point light, or a point light parallel with (facing or opposite to) the view direction. A point light source could be transformed into a normal point light, an inverted point light, or a directional light if the point light lies on the camera plane (the plane goes through the viewpoint and perpendicular to the view direction). The maximal benefit from the approach is when a directional light in the world space is perpendicular to the view direction (where it remains as a directional light after projection transformation), and a point light is far away from the viewing frustum. Common problems in shadow mapping like shadow acne, are worse in this approach.

The shadow map should contain all objects within the view frustum and all potential occluders outside the frustum. In world space, the paper collects the objects within an area defined by the common part of the scene, the light frustum, and the convex hull of the view frustum and light position. In post-perspective space, however, while the lines are still lines, the order of points along a line can change. It's possible that points behind the viewer have to be included, but they are projected beyond the infinity plane. As one solution, in this case, would be generating two shadow maps, the paper chooses to shift the camera towards the opposite direction of the view direction so that this problem will not happen. The problem is that this approach will gain no advantage against a uniform shadow map in this case, but it's noticeable only when the light source is far behind the viewer, which will lead to the proposed approach converge to the normal shadow map anyway.

The implementation of the approach results in 15 FPS for Notre Dame scene with a crowd and trees on an NVIDIA GeForce3 and 10 FPS for a scene contains moving cars and airplanes, which perspective shadow maps of size 1024x1024. A complete ecosystem scene consisting of hundreds of different plants is also included in the test, and the improvement with using perspective shadow map is significant.

In conclusion, the proposed perspective shadow maps permit the generation of shadow maps with a significantly improved quality compared to standard shadow maps. The method is appropriate for both large and complex scenes and interactive applications. It can also fully utilize modern graphics hardware while still be suitable for software renderers.