Summary of *Comparison of Projection Methods for Rendering Virtual Reality*

Victor Shu

This paper evaluated several techniques of rendering for head-mounted displays in VR. As a typical display presents the image with grids of pixels, the story for HMDs is different, where they have a much wider field-of-view, and the displays are hidden behind a lens system, which can make the display appear at a distance, as well as distort the display to counteract the sparse angular pixel density of a regular display. Since the rasterizer works the best on uniform grids and will likely remain the same, there is an additional distortion stage before being displayed, which comes at a cost, as more pixels should be rendered at highly distorted areas.

There are several algorithms for rendering images for VR described in this paper. Cube Projection (CUBE), created for rendering fisheye-distorted images for the Omnimax projector, has two versions, where the first one renders directly to the required non-linear space, and the other one renders to a cube map and combines them. Multi-Res Shading (MRS), introduced by NVIDIA, divide a single projection plane into a grid of sub-projections, of which the resolution can be controlled individually. Multi-Plane Projection (MPP) takes a step further that it also allows the sub-projections to tilt, stretch, and shear.

The paper used four HMDs: StarVR, HTC Vive Pre, Oculus DK2 and Oculus DK1, and two variations of the described algorithms called constrained and non-constrained which means whether the resolutions of a sub-projection is constrained such that the neighbor sub-projections will have the same amount of pixels along the edges, to render five scenes from PBRT. The test shows that using multiple sub-projections gives all devices benefits in the number of rendered pixels, and MPP 3x3 shows the best result. The paper used a high-quality imaged ray-traced directly in distorted space as a reference to evaluate the PSNR. The result shows that the choice of algorithm is pretty much indifferent to render quality. The paper also evaluates the bin spread as a function of object size.

From the test results, it is clear that all algorithms can generate high-quality images, and most of them are better than baseline even though the implementations focus on performance instead of quality. As for the performance, the paper indicates that it is always good to use multiple sub-projections which can reduce the pixels rendered up to 64% compared to the baseline. The number of pixels rendered also depends on the amount of distortion, where devices with highly distorted displays have more advantage than the ones that do not. The results also show that if an object is contained entirely within a single sub-projection, it will not create significant overhead. Moreover, since the implementation is not optimized, most overheads come from rendering objects multiple times. With modern graphics APIs, this overhead could be dramatically reduced. The paper also indicates that using multiple sub-projections will make screen-space processing techniques more difficult to implement.

As a summary, the paper states that rendering for devices with wide FoV with eye-tracking will be an important direction for future works. A user study about acceptable ad-hoc resolution target maps for different devices is also going to be useful. Finally, screen space effects need to be re-implemented to fit the distortion of the sub-projections.