

	covered (K pix)	rendered (K pix)	overdraw	vertex (ms)	geometry (ms)	raycasting (ms)	lighting (ms)	shadow (ms)	texturing (ms)	Total (ms)	Ratio
GL		249	0%	0.40	-	-	0.33	0.06	0.45	1.25	100%
ST	308	173	78%	0.41	0.57	0.13	0.34	0.57	0.24	2.25	180%
PT	406	197	106%	0.41	0.69	0.16	0.39	0.70	0.17	2.52	202%
SQ	897	173	418%	0.41	0.40	0.33	0.44	0.26	0.36	2.20	176%
PQ	714	181	294%	0.40	0.36	0.29	0.42	0.22	0.37	2.06	165%
Lens1	5089	172	2859%	0.40	0.47	2.55	0.53	0.61	0.65	5.21	417%
Lens2	5006	172	2810%	0.40	0.44	2.00	0.79	0.49	0.62	4.74	379%
600	702	181	288%	0.39	0.16	0.26	0.44	0.17	0.13	1.55	128%
2800	714	181	294%	0.40	0.36	0.29	0.42	0.22	0.37	2.06	165%
4900	786	182	332%	0.45	0.52	0.29	0.43	0.27	0.49	2.44	185%
Temple PQ	1950	250	680%	0.17	0.33	0.77	0.63	0.42	0.57	2.88	461%
Patio PQ	1271	335	279%	7.55	31.47	0.86	0.24	5.93	38.28	79.85	600%

Table 3: Rendering times for our algorithm, with the cost of the different steps. The first 7 lines are for the Facade scene (2800 triangles), for several projection methods: **GL** (standard GLSL rendering with per pixel lighting), **Sx** is Spherical map; **Px** is Parabola map; **xT** uses triangles enclosing shape; while **xQ** uses quad bounding box. The next three lines are for Facade with different scene complexity for the PQ algorithm. The last two lines are for larger scenes.

6 Conclusion and Future Directions

In this paper, we have presented a robust algorithm for handling specific non-linear projections inside the graphics pipeline. Our algorithm works both for direct display of the non-linear projection, e.g. a fish-eye lens inside a video game, or for indirect use, e.g. when rendering a shadow map with a paraboloid projection.

As with previous work, we start by bounding the projection of each shape, then discard extra fragments inside the bounding shape. Our contributions are twofold. First: two different methods for bounding the non-linear projections, one based on triangles that is optimal in fragments but requires more work in the geometry engine, the other based on quads that is optimal for the geometry engine but can cause more overdraw. Second: a mathematical analysis of several non-linear projection methods, where we show that some of them have simple expressions, and thus lend themselves to easy bounding through geometric tools.

Although non-linear projections are slower than linear projections, the extra cost is manageable. As a single non-linear projection can replace up to five linear projections (in a hemicube), it can even be a practical alternative, both for rendering time and memory cost.

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