

MSAA-Based Coarse Shading for Power-Efficient Rendering on High Pixel-Density Displays

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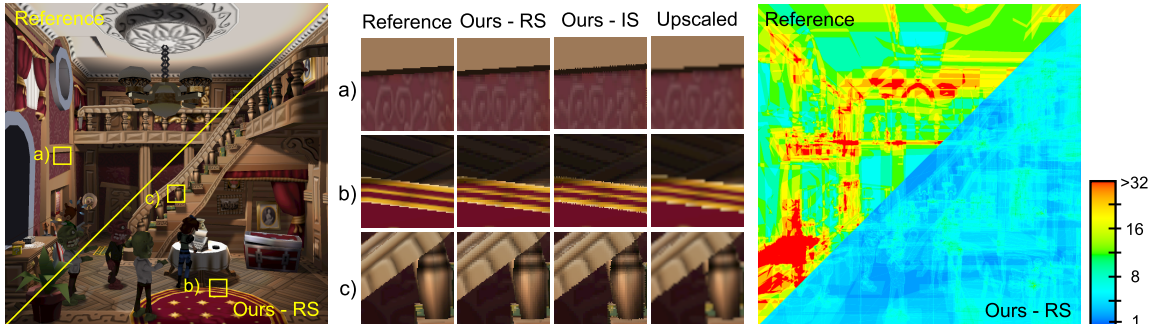


Figure 1: Our technique reduces the total number of pixel shader invocations (by 3.63× in this scene) when compared to standard per-pixel shading, resulting in a reduction of the total rendering time and power consumption. The clarity of geometric edges is preserved and the resulting image shows very few perceivable differences when observed on a high pixel-density display. The heatmap measures the number of shader invocations per 2×2 pixel block. RS: Regular Sampling. IS: Interleaved Sampling. Modeling and texturing by Glen Fox.

1 Introduction

Maintaining real-time frame rates at the native resolution of high pixel-density displays is very challenging, especially on power-constrained mobile devices. For this reason, many applications render at a lower resolution and upscale the results. *Decoupled sampling* approaches offer a better solution to this problem, by sampling the visibility at a higher rate than shading, thus preserving the clarity of geometric edges, while reducing the cost of shading. However, this ability is rather limited in current graphics architectures, where the widely-used MSAA algorithm shades each covered primitive at least once per pixel, without directly providing the ability to compute pixel shading at a more coarse rate. While various extensions of the graphics pipeline for coarse shading have been proposed [Vaidyanathan et al. 2014; He et al. 2014], in this work we focus on a software implementation for existing GPUs.

2 Method Overview

In our approach, we render an intermediate render buffer at a lower pixel count, but at the same time we compensate the loss in resolution by adding the appropriate amount of MSAA sub-pixel samples, in order to guarantee *at least* one visibility sample per display pixel. Subsequently, a custom resolve shader is used to perform the mapping of sub-pixel MSAA samples to pixels. This simple technique effectively shades more coarsely pixel blocks where there are no geometric edges. While variations of this idea have been previously used on game consoles, a proper evaluation of the effectiveness of this method at decreasing shader invocations and energy consumption is missing from the bibliography and is our main contribution.

Interleaved Sampling. Our technique inherently creates spatially interleaved sampling patterns, where adjacent pixels always use different sample positions. This can replace regular aliasing artifacts at polygon edges with noise. If desired, the interleaving can be disabled by explicitly controlling the MSAA sample positions.

Scene Name	PPS (Watts)	Ours (Watts)	Reduction
2D Pattern	4.9	4.4	10.2%
Mansion	8.7	7.6	12.6%
Sponza	32.4	17.6	45.7%
Vol. Shadows	29.7	16.1	45.8%

Table 1: Power consumption metrics for our approach compared to standard per-pixel shading (PPS). Tested on an MacBook Pro 13” (late 2013 model) with v-sync enabled.

3 Results

Table 1 shows the SoC (CPU and GPU) power consumption when rendering a number of representative test scenes with standard per-pixel shading and our method. These measurements indicate that the more coarse shading of our approach translates to large power-savings. Power consumption was measured using the energy counters of the processor and the *Intel Power Gadget* tool. Vertical sync was enabled to ensure that we compare the energy for the same amount of work (same frame-rate) for each rendering method.

Discussion. Since the intermediate render buffer has less pixels, our method decreases the number of pixels covered by each projected triangle. This has a negative effect on the efficiency of many hardware rasterizers, reducing the potential gains of our method.

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References

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- VAIDYANATHAN, K., SALVI, M., TOOTH, R., FOLEY, T., AKENINE-MÖLLER, T., NILSSON, J., MUNKBERG, J., HASSELGREN, J., SUGIHARA, M., CLARBERG, P., ET AL. 2014. Coarse pixel shading. In *High Performance Graphics*, 9–18.

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