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

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1. Motivation

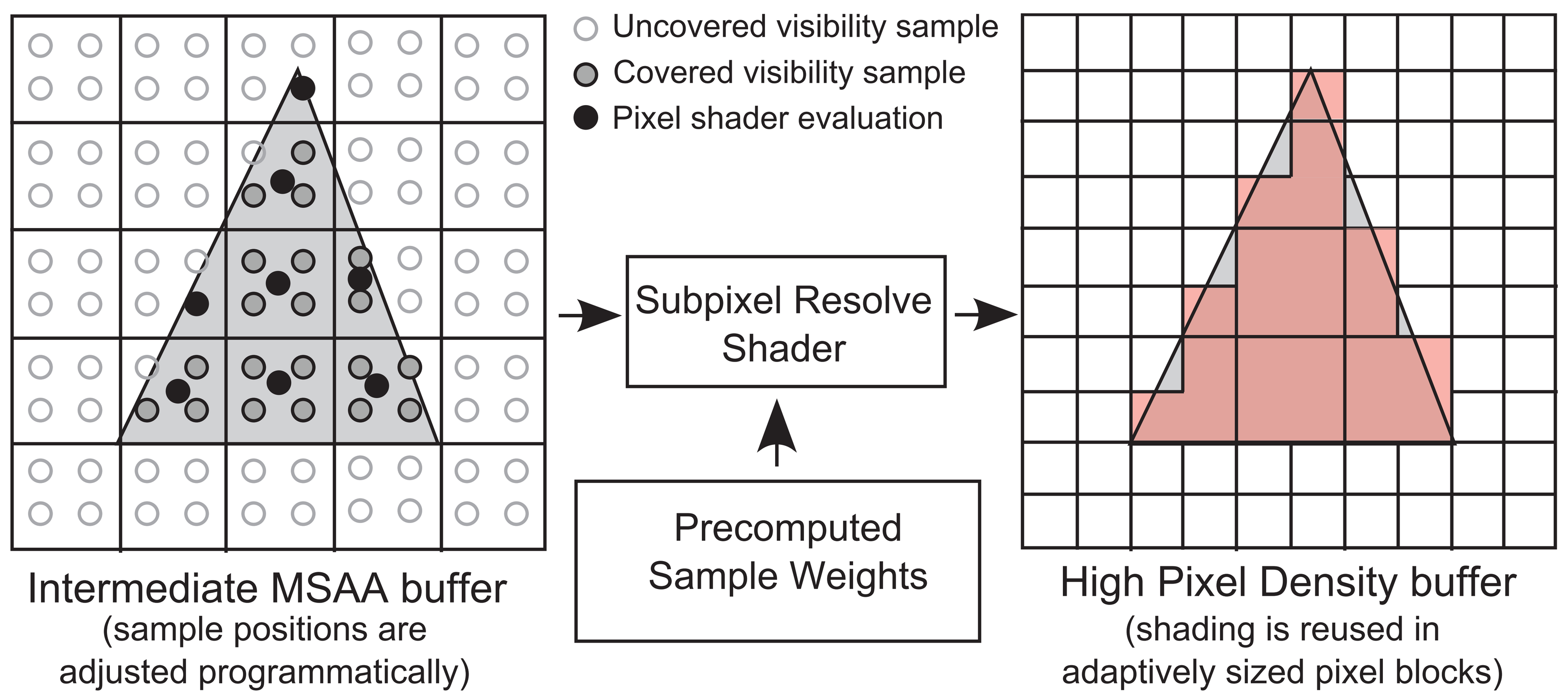
Maintaining real-time frame rates at the native resolution of high pixel-density displays is very challenging, especially on **power-constrained mobile platforms**. *Decoupled sampling* methods offer a solution by reusing the same shading color across multiple visibility samples, but this ability is rather limited in modern GPUs, where the widely-used MSAA algorithm shades each covered primitive *at least once per-pixel*, without directly supporting more coarse shading. While various extensions of the graphics pipeline for coarse shading have been proposed [1][2], in this poster we focus on a software implementation for existing GPUs.

2. Contributions

- We present an MSAA-based method that reduces the total number of fragment shader invocations by shading more coarsely pixel blocks that are covered by the same primitive.
- We measure a large reduction of power consumption compared to standard per-pixel shading in a number of scenes.

Our **forward-rendering** approach relies on standard APIs and HW capabilities and is suitable for current GPUs **(OpenGL ES 3.1).**

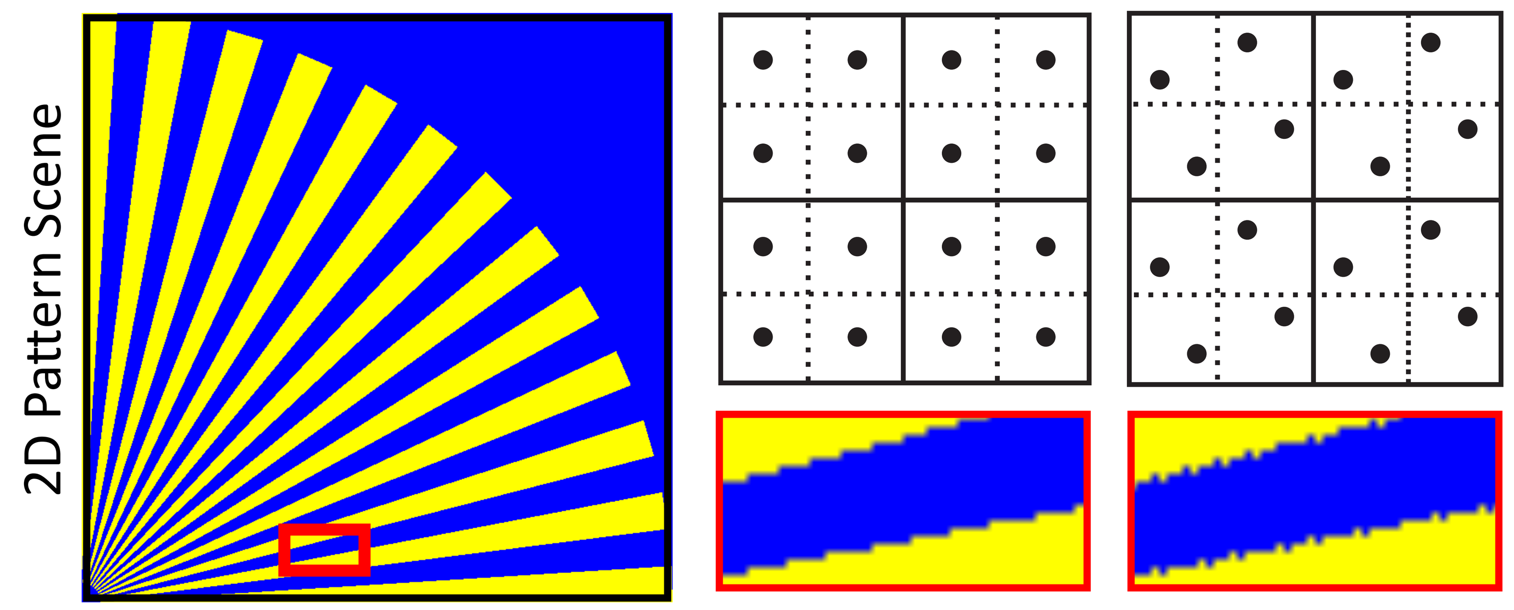
3. Method Overview



Step 1. Render at a lower pixel resolution, but with additional MSAA samples to **guarantee at least one sample per screen-pixel**.
Step 2. A custom resolve shader performs the mapping of sub-pixel MSAA samples to screen pixels.

Centroid Sampling should be used when rendering the inter-mediate render buffer.

4. Interleaved Sampling

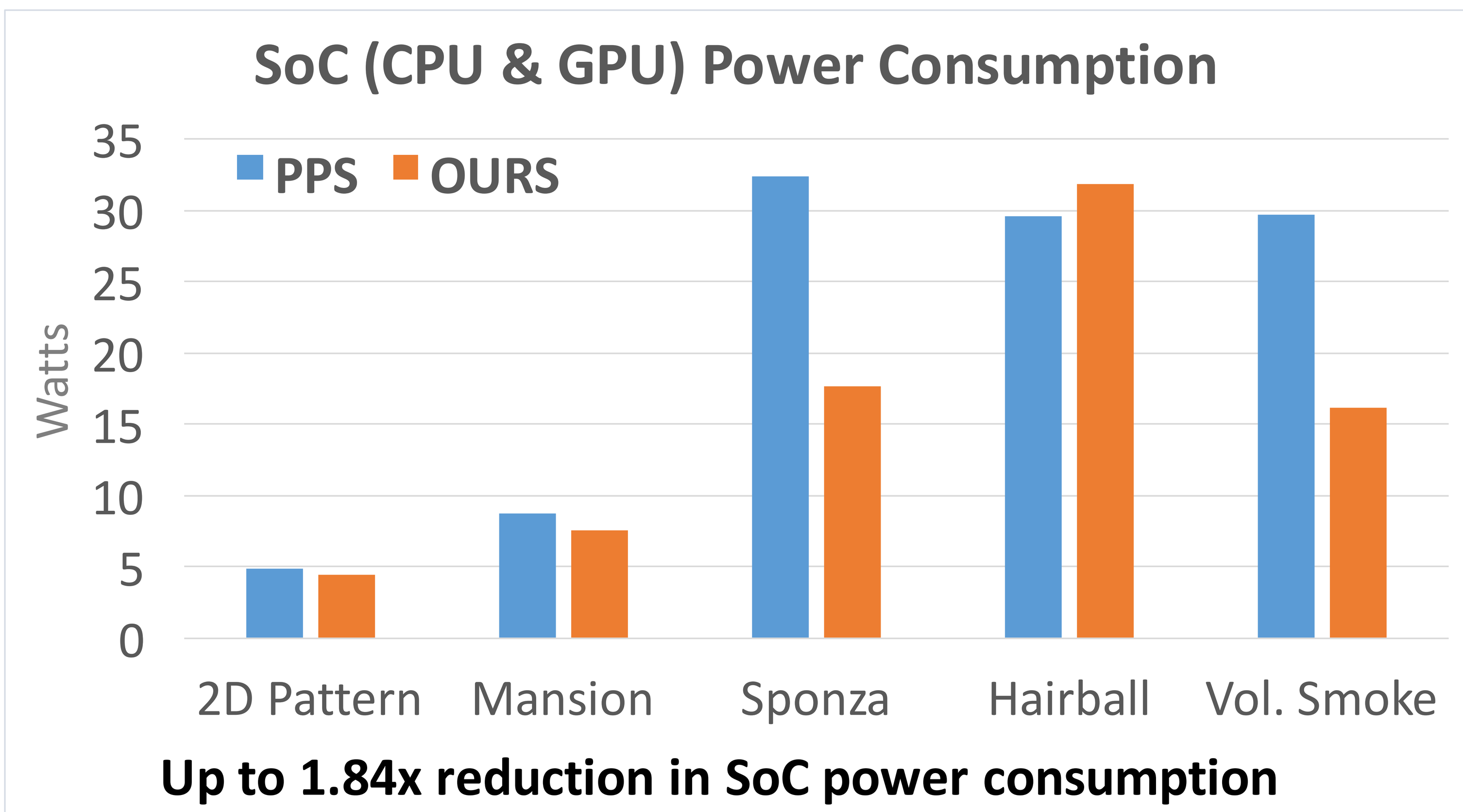


Spatial Interleaving. Adjacent pixels have different sampling patterns. Masks aliasing artifacts at polygon edges with noise. Can be disabled using programmable MSAA sample positions.
Temporal Interleaving. Alternate between two sampling patterns at successive frames. Requires 60+Hz rendering and v-sync.

5. Results

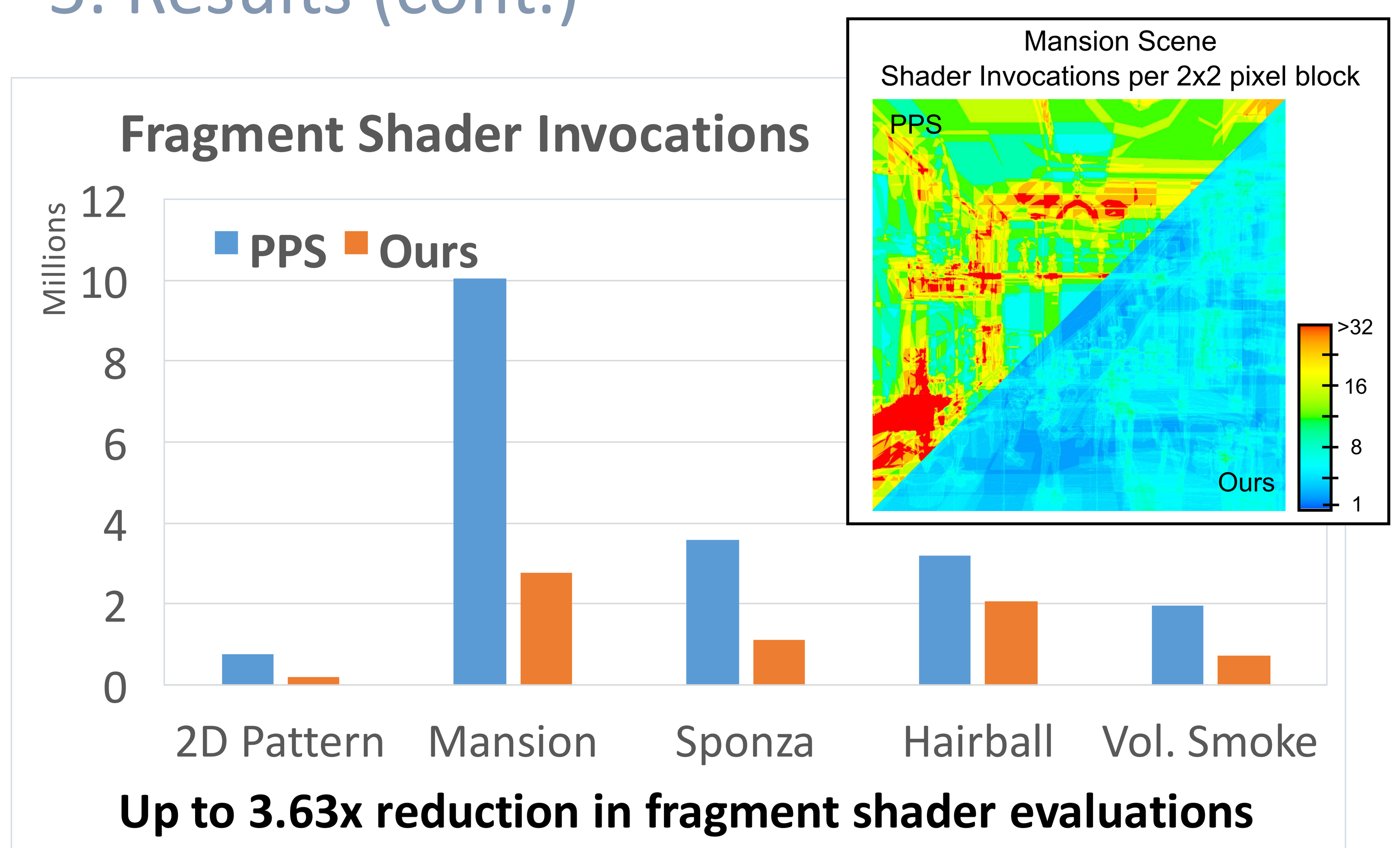
Scene	SSIM (%)	PDiff (%)	PSNR (db)
2d Pattern	99.9	0	53.8
Mansion	95.6	0.01	34.3
Sponza	81.2	0.05	29.5
Hairball	97.6	0.08	31.8
Vol. Smoke	96.5	0	42.5

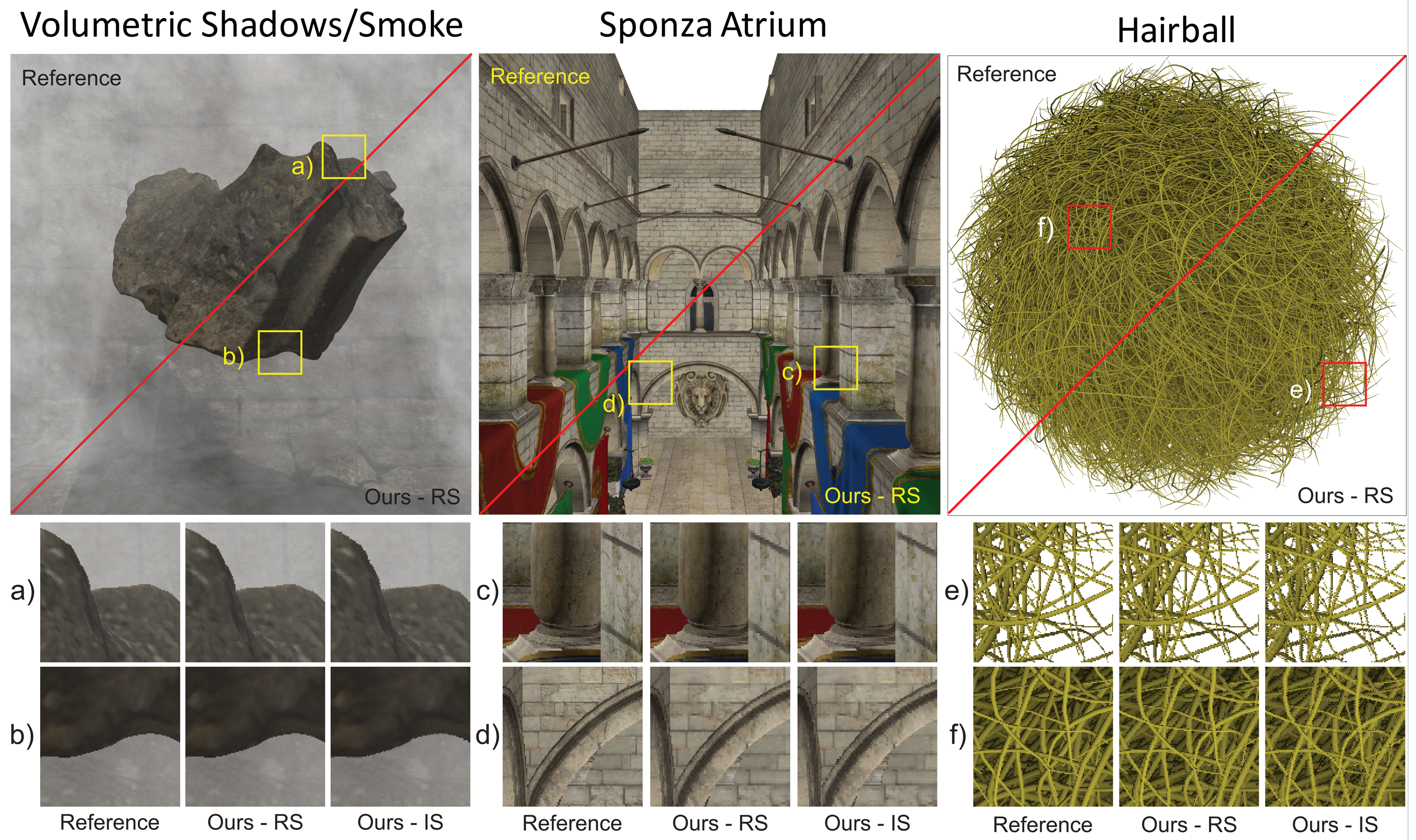
Table 1: Image quality metrics of our technique compared to standard per-pixel shading **(PPS)**.



Measured on a **Macbook Pro 13''** (late 2013 model) using the *Intel Power Gadget Tool*.

5. Results (cont.)





The resulting images show **very few perceivable differences** compared to per-pixel shading, *when observed on a high pixel density display.*

6. Discussion

Triangle Size. Less pixels are covered by each triangle, negatively affecting the efficiency of many HW rasterizers.
Compression. Reading from MSAA render buffers might disable compression or trigger a decompression operation on some HW architectures.

7. References

[1] VAIDYANATHAN, K., SALVI, M., TOTH, R., FOLEY, T., AKENINE-MO¨LLER, T., NILSSON, J., MUNKBERG, J., HAS- SELGREN, J., SUGIHARA, M., CLARBERG, P., ET AL. 2014. Coarse pixel shading. In High Performance Graphics, 9–18.

[2] HE, Y., GU, Y., AND FATAHALIAN, K. 2014. Extending the graphics pipeline with adaptive, multi-rate shading. *ACM Trans. Graph. 33*, 4 (July), 142:1–142:12.

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