Breaking the Frame: A New Approach to Temporal Sampling

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1. Introduction

Realtime rendering requires fast and accurate display of a dynamic scene. Frameless rendering offers unique flexibility in rendering. Because it samples time per pixel, it can respond to change with very little delay, and at any location in the image. IO-Differencing in a novel technique for trading off spatial fidelity (how accurate the image is rendered) against temporal fidelity (how often or quickly the image is rendered). Quantizing IO-difference in terms of visual error (temporal and spatial error) introduced during rendering can serve as a useful feedback to the rendering engine which than focusses more upon the areas of change in the image so as to optimize image update based on how view is changing and on how objects are moving. Such quantization must be efficient both in terms of computation and its ability to indicate plausible areas of change.

2. Implementation

We measure IO-Difference as temporal error by monitoring color change in the image. This is done by measuring the squared color difference between colors at a pixel in previous and current rendering. A probability distribution function (PDF) is used to choose the next pixel rendered so that changing image regions are sampled more frequently. The probability of every pixel is the weighted sum of its temoral error and its age (time since it was last updated) both normalized over the entire image. The former biases towards high temporal contrast image regions and the latter monitors for change in previously static image regions. This ensures that all pixels are sampled with a certain minimal frequency. The image space is subsampled into rectangular tiles. Besides bringing obvious improvements in speed, subsampling implements a spatially coherent response to change: if one pixel is changing, neighboring pixels are likely also changing. Probability for every tile is computed by similar weighted sum of average temporal error and age of its constituent pixels. When sampling this coarser version of image space, we first select the tile according to the PDF, and then randomly select a pixel within that tile or one of its neighbors with bilinear interpolation of the surrounding tile probabilities just as in bilinear texture filtering.

3. Results

Our resulting improved renderer displays sharper imagery with fewer rays as shown in figure 1 and 2. These figures are frames of a video at a simulated rendering rate of 900,000 rays per second. In interactive use, our renderer casts roughly two thirds as many rays per second as the standard renderer, but the resulting images are still sharper.

4. Future Work

Our future work in this area would be to tune our system more effectively, gauging the effect of different tiling resolutions and values for R in display environments with varying patterns of change. We have used squared color difference to get temporal error, which is both easily calculated and surprisingly effective

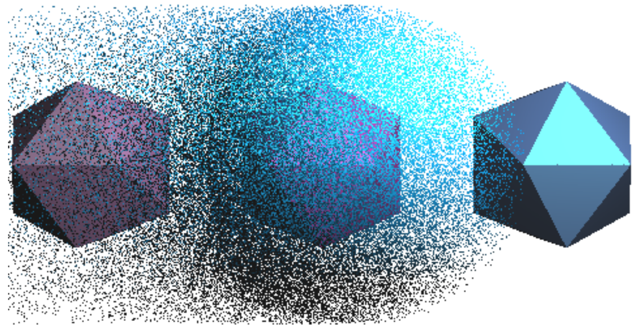

Figure 1: Traditional fully random frameless rendering. A sphere moves across quite visible background objects.

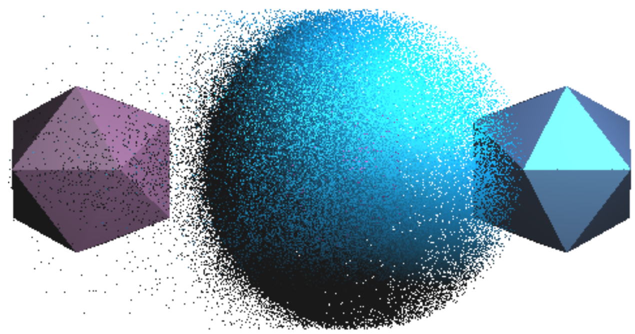

Figure 2: A frameless renderer that responds to change. The same sphere now occludes the background with fewer rays.

in predicting visual differences. However, it may prove useful to use more complex perceptually based differencing approaches that have stronger and perhaps frequency-based response to spatial contrast. For example in such color based approach change along edges is perceptually more important than that in the interiors. Other techniques for measuring visual error in terms of camera and object motion, distance between object and camera etc. will also be good to explore. We also hope to incorporate progressive spatial rendering into our frameless prototype with the use of splats and prefiltered models. The renderer would then have to decide not only where to render, but also what level of detail to use.

4. References

BISHOP, G., FUCHS, F., MCMILLAN, L. & ZAGIER, E. 1994. Frameless Rendering: Double Buffering Considered Harmful. In *Proceedings of SIGGRAPH 1994*, ACM Press / ACM SIGGRAPH, New York. A. Glassner, Ed., Computer Graphics Proceedings, Annual Conference Series, ACM, 175-176.