Interactive Summed-Area Table Generation for Glossy Environmental Reflections (sketches_0193)

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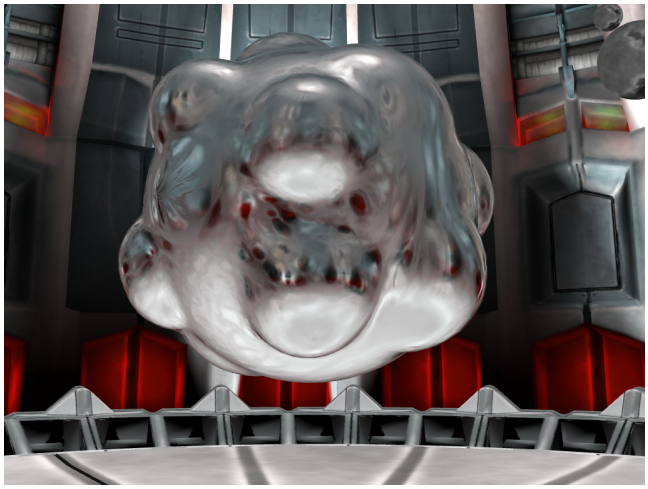

Figure 1: Environment map filtered with a procedurally generated spatially varying filter (frame renders at over 50 fps).

1 Introduction

There are many applications in computer graphics where spatially varying filters are useful. One example is the rendering of glossy reflections. Unlike perfectly reflective materials, which only require a single radiance sample in the direction of the reflection vector, glossy materials require integration over a solid angle. Blurring by filtering the reflected image with a support dependent on the surface's BRDF can approximate this effect. This is currently done by pre-filtering off-line, which limits the technique to static environments. Crow [Crow 1984] introduced summed-area tables to enable more general texture filtering than was possible with mip maps. Once generated, a summed-area table provides a means to evaluate a spatially varying box filter with a constant number of texture reads.

2 Summed Area Table Generation

In order to efficiently construct summed-area tables, we borrow a technique, called recursive doubling, often used in high-performance and parallel computing. Using recursive doubling, a parallel gather operation amongst n processors can be performed in only $log_2(n)$ steps, where a single step consists of each processor passing its accumulated result to another processor. In a similar manner, our method uses the GPU to accumulate results so that only O(log n) passes are needed for summed-area table construction.

Glossy Environmental Reflections In [Kautz et al. 2000], Kautz et al. presented a method for real-time rendering of glossy reflections for static scenes. They rendered a dual-paraboloid environment map and pre-filtered it in an offline process. Instead of pre-filtering, we create a summed-area table for each face of a dual-paraboloid map on the fly, and use them to filter the environment map at run time. This enables real-time, interactive environmental glossy reflections for dynamic scenes

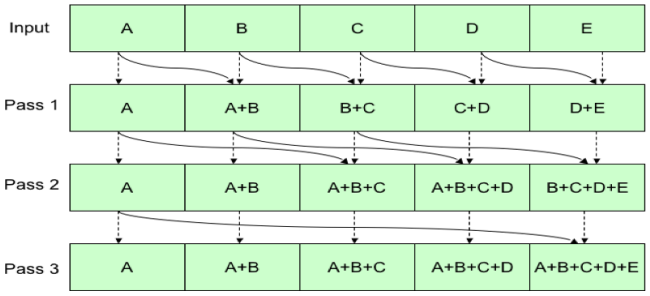

Figure 2: The recursive doubling algorithm in 1D. On the first pass, the value one element to the left is added to the current value. On the second pass, the value two elements to the left is added the current value. In general, the stride is doubled for each pass. The output is an array whose elements are the sum of all of the elements to the left, computed in O(log n) time.

Improving Precision In order to mitigate the loss of precision associated with summed-area tables, our approach modifies the original summed-area table computation. The modification is to represent pixel values in the original image as signed floating-point values (e.g., values in the range -0.5 to 0.5), as opposed to the traditional approach which uses unsigned pixel values (from 0.0 to 1.0). This modification improves precision in two ways: (i) there is a 1-bit gain in precision because the sign bit now becomes useful, and (ii) the summed-area function becomes non-monotonic, and therefore the maximum value reached has a relatively lower magnitude.

3 Conclusion

We have introduced a technique to rapidly generate summed-area tables, which enable constant-time space varying box filtering. This capability can be used to simulate a variety of effects. We have demonstrated glossy environmental reflections. The biggest drawback to summed-area tables is the high demand they make on numerical precision. To ameliorate this problem, we have developed some techniques to more effectively use the limited precision available on current graphics hardware.

References

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KAUTZ, J., VAZQUEZ, P.-P., HEIDRICH, W., AND SEIDEL, H.-P. 2000. A unified approach to prefiltered environment maps. In *Eurographics Workshop on Rendering*.

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