An Object Space Approach to Shadowing for Hair-shaped Objects

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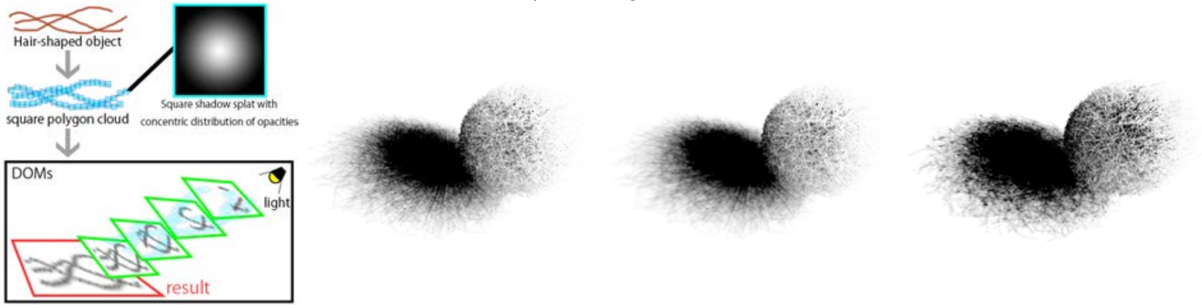

(a) *Workflow* **(b)** *Conventional DOMs* **(c) (b)** *followed by anti-aliasing* **(d)** *Our method*

Figure 1: *The proposed method simply uses a cloud of variable-sized square shadow splats to compute DOMs in order to ameliorate spatial/temporal aliasing artifacts appearing in the shadows of intricate shapes like mass of thin strands.*

1 Background and Purpose

Three-dimensional objects can be rendered more realistically with their shadows. Commonly-used shadowing methods based on textures with depth values are unfortunately likely to cause aliasing, which is usually ameliorated by such image-space post-processing as neighboring pixel averaging or variance-based smoothing. However, spatial/temporal aliasing can still be observed in pieces and films of work when bundles of thin strands like human hairs are targeted. We can generate sharp shadows even from such intricate shapes if we suitably move their vertices or expand their mesh at the sacrifice of extra computation. Our method attempts to tackle this type of aliasing problem in a simpler manner by generating anti-aliased shadow splats in the object space.

2 Proposed Method

Our method relies mainly on Deep Opacity Maps (DOMs) [Yuksel and Keyser 2008], which record depth values as well as density values for each of the intersecting objects along rays from an eye as a texture of opacity distribution, and then refer to these recorded opacity values to compute the attenuated light power distribution for final shadow, as shown in Fig. 1(a). Darkness of shadows can be modified by adjusting the opacity values stored in the maps.

For the purpose of shadowing, our method generates from the target object, a cloud of square-shaped shadow splats, which have two characteristics. First, each splat has its concentric distribution of opacities decreasing from 1 (center) to 0 (perimeter) in order to smooth opacity distribution at overlapped splats. Second, each splat is placed to be perpendicular to the ray direction, and the size of all the splats can consistently be adjusted in the orthogonal directions on-the-fly according to users' specification. Contribution of more splats to the summed darkness of a fixed position results in smoother shadow gradients.

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In Fig. 1(b)–(d), we use the Hairball model [McGuire 2011] to compare the result of our method with those of conventional DOMs with/without anti-aliasing. The use of slightly-larger shadow splats can inhibit undesirable separation and gaps of shadows coming from tiny objects placed a bit sparsely with one another. The accompanying video proves that our method also succeeded in ameliorating temporal aliasing appearing in the Hairball animation more effectively than the conventional methods.

The proposed method can be combined with others. For example, one is allowed to use depth maps only for shading and to use our method for shadowing. In this case, DOMs can be simplified only to use one opacity map. The proposed method is applicable to other scenes with a set of tiny objects such as leaves, smoke, and tornado.

3 Limitations and Issues

In order to render the hairball model shown in Fig. 1(d), $2,880,000$ shadow splats with 512×512 pixels were used. In the current implementation, a shadow splat is given to each of the object patches at its centroid, and DOMs use just four opacity maps. When we used a standard PC, our code ran in real-time, though it was slower than conventional DOMs with anti-aliasing in Fig. 1(c).

The proposed method can be parallelized easily with GPUs as it owes many simpler-shaped primitives to generate shadows. Further acceleration would be possible by letting a single shadow splat be generated for multiple neighboring object patches. The use of locally-adjusted, variable-sized shadow splats is expected to increase the quality of resulting shadows while keeping the computational speed low. If we make use of volumetric shadow splats, the present method could be naturally extended so as to use multiple light sources.

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References

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