Rendering Hair-Like Objects with Indirect Illumination

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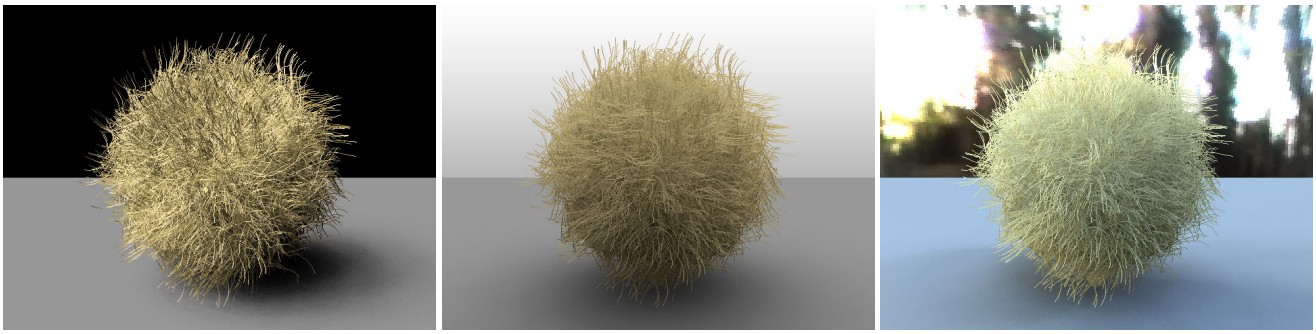
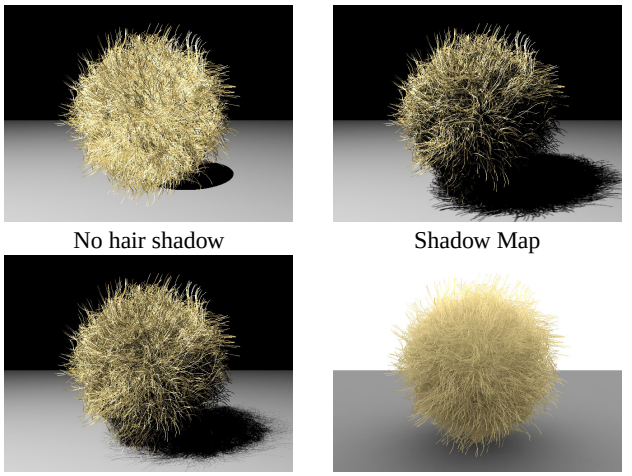


Figure 1. Our method with an area light (left image), an ambient occlusion (center image) and with a HDR map publicly available at www.debevec.org (right image).

Hair self-shadows are extremely important in visualizing hair structure. Existing methods can only handle self-shadows from a point light source. We present **a projection based framework for Indirect illumination of Hair-Like Structures which has never been done before.** Using our framework, it is possible to calculate self shadows resulted from indirect portion of Global Illumination (GI)[1]. Our framework simple and straightforward to be implemented by any good graduate student.



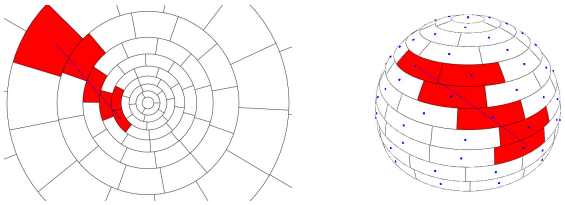
No hair shadow | Shadow Map

Deep Shadow Map [1] | Our method with white skylight

Figure 2: Comparison with other methods.

This framework allows us to render images that have not been created before. The Figure 2 shows a comparison of images that is created by our framework to those that are created by shadow map and deep shadow map. The extreme simplicity of the hair model allows us to identify the contribution of our rendering method to the appearance. As seen in this figure, the basic shadow mapping represents a significant improvement over no-hair-shadow. The deep shadow map method further improves this result by taking transparent shadows into account. However, both of these methods work only for direct illumination by point and single directional light sources. In our framework, we calculate the visibility for each shading point, so that self-shadows that are resulted from indirect illumination coming from every direction can be included. This framework can also be used for sky light, area light sources, image based illumination and final gathering stage of photon mapping.

Our framework is based on a visibility calculation method that is suitable for the scenes populated with line segments such as hair. For every shading point, we calculate visibility from every direction using projection of line segments. This visibility calculations can be implemented by any hemisphere based projection method. We have developed a new hemisphere based method that use a shape that resemble Igloo. Using igloo, visibility problem reduces to line-circle intersections on an infinite plane (see Figure 3). The framework can also be implemented using other approximations of hemisphere such as Hemicube.



(a) (b)

Figure 3: Line and face intersections on an Igloo.

We have also developed a set of simplifying assumptions that reduce the computation time significantly. The images shown here are rendered in 10 minutes on a Pentium4 3GHz processor. One of our simplifying assumptions comes from the fact that the real hair strands usually form clusters. Although, our hair model is completely random, our results show that the assumptions still hold. Note that we did not include any tricks like using slightly different colors for each hair strand or different hair colors for root and tip that will make the images look more realistic. Still, even in very uniform lighting conditions, hair self shadows help to see the 3D structure of the hair, which would otherwise look flat. In animated sequences we do not get any artifacts with motion since our simplifying assumptions are deterministic.

[1] T. Lokovic and E. Veach, "Deep Shadow Maps", Proceedings of SIGGRAPH 2000, 385-392.

[1]Global Illumination methods that are based on ray tracing have never been implemented for hair-like structures since it is not feasible to find intersections with thin lines with any derivative of ray-tracing.