Semi-Realistic Rendering of Fur via Shell Method

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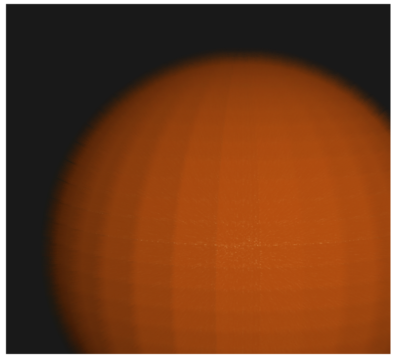

Abstract

With this project the authors hope to implement a fur render similar to the work of [Kajiya and Kay 1989]. This renderer allows the rapid creation of semi-realistic fur textures by creating a series of "shells" - meshes layered on top of a model like layers of an onion - and rendering each layer with a noise function to simulate individual strands of fur. The shell method is significantly faster than traditional geometry based renderers, allowing real time rendering speeds. The downsides to this method are a potential loss of realism as well as increased difficultly accounting for effects such as gravity or wind.

Keywords: rendering, fur simulation, volume density

1 Introduction

Realistic rendering of fur style textures allows a vast number of scenes to be rendered in a visually appealing manner. Everything from the short fuzz of a carpet to the curly beard of an old man can be represented by a fur texture. However, previous attempts at creating a realistic model relied on geometry based methods, rendering each hair, or group of hairs, as an actual object. While accurate, these methods increased render time exponentially, and the hundreds of finely detailed polygons could often interact in non-obvious and unintentional ways. Both these problems can be solved by relying, not on a fastidiously accurate geometric model, but on an approximate model, one that visually matches the results of a more complex rendering, without the overhead.

2 Related Work

The method detailed in this paper is based mainly upon the work of Kajiya and Kay [Kajiya and Kay 1989] however, several aspects of the projects design were adapted from the work of Papaioannou, G [Papaioannou and Panepistimioupolis 2002] as well as the work of Praun et al. [Praun et al. 2000]. Previous renderers were geometry based, or volumetric [Neyret 1998].

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3 Technical Approach

3.1 Shells

To simulate the effect of fur on a surface, a series of shells is created around the object. These shells maintain the shape of the object, but increase in size, in a fashion similar to nesting matryoshka dolls. These shells form the basis for the fur simulation. Each shell receives a texture based upon a uniform random density distribution

$$P_n = \begin{cases} \frac{1}{(b-a)} & x \in [a, b] \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

These textures determine to position of individual hairs in the model. To transition between the density maps and the fur texture, each map is thresholded at a certain value with the threshold increasing as a function of the shell level. The increasing threshold values thin the point density of each level, simulating the decreasing volume density of fur from root to tip. Once the map is thresholded, the intensity at each point in the map I is mapped to the opacity α of each shell.

$$\alpha = \begin{cases} I & \text{I} \geq \text{T} \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

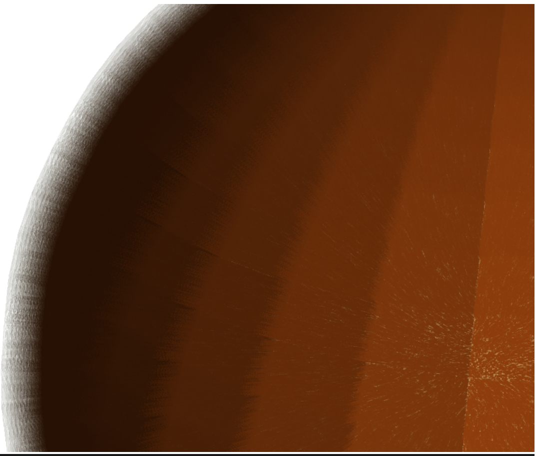
This means that areas of high point density are rendered opaque, while areas of low density are transparent.

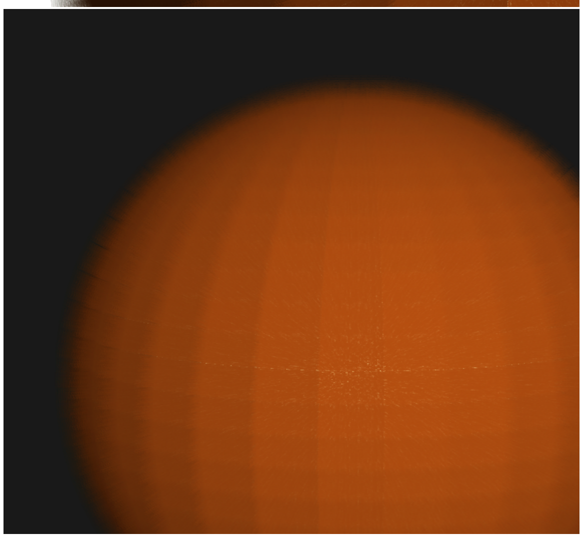
3.2 Lapped Textures

To facilitate the creation of shells over arbitrary surfaces, each surface is divided into a series of overlapping patches. Once the patches are created, each patch then has a series of shells built on top of it. This method allows rapid creation of shells over complex geometry, even if the geometry is non-manifold. This method is very similar to the method proposed by [Lengyel et al. 2001] and is based upon the work of [Praun et al. 2000].

To create the patches a random patch is selected from the model. If the poly is currently in a patch, then it is discarded, and a new random quad is selected. If the quad is not in a patch, then a new patch is created. From this initial quad the patch is expanded in a spiral pattern until the maximum patch size is met. No attempt is made to prevent patches from overlapping, not only does this ensure total coverage of the object, the overlapping patches help hide patch edges in the fur texture, as the non-regular overlapping prevents repetitive seam edges.

4 Results





5 Future Work

Further work must be done to determine the proper parameters to the model to create a render free from obvious defects, however this does not require further development of the rendering model. Extending this project, the authors hope to implement ray-tracing in the fur model allowing accurate shadow generation. The shadows in particular are important as they give a sense of depth to the fur, increasing the believability of the final render. Other improvements might include the introduction of guiding forces, such as gravity or a curling factor, which the authors were not able to include due to time restraints.

6 Timeline

The project took the whole 4 weeks to complete. Sloan worked on shells and rendering, while Artem worked on patches and opacity maps.

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