Acquiring Shell Textures from a Single Image for Realistic Fur Rendering

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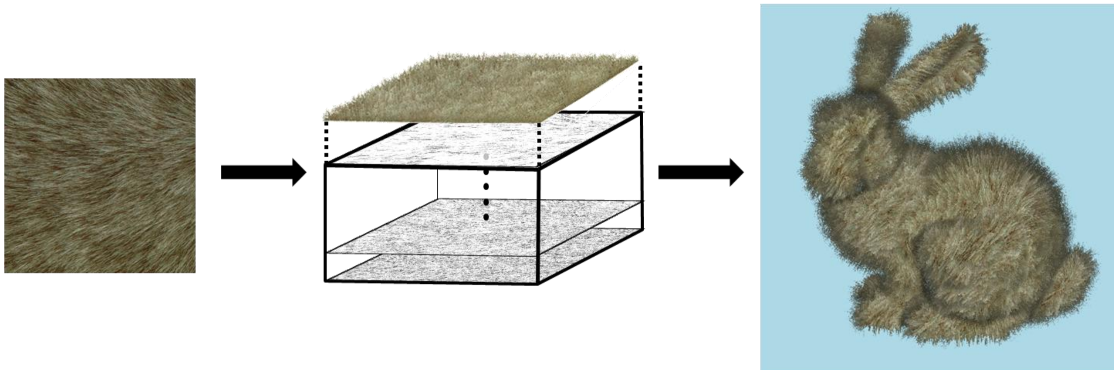

(a)input image (b)layered shell textures (c)synthesized furry model

Figure 1. Workflow of our method and result image

1. Introduction

To synthesize a realistic appearance of mammals, it is necessary to express disorderly lie of hairs. "Shell texturing method", proposed by Lengyel [2001], is possible to synthesize realistic fur appearance over arbitrary surfaces in real-time. Prior to rendering, it is necessary to prepare several shell textures as a pre-process. However, acquiring appropriate shell textures is a complicated and time consuming work. In this paper, we present a novel method to acquire shell textures only from a single input picture of an actual animal fur. Since every shell textures are automatically computed by a pixel shader in run-time, it is not necessary any complicated pre-computation. Furthermore, conventional shell texturing method employs typically 16 textures which require huge graphics memory. Because our method requires only a single texture, we realize a significant reduction in memory usage for practical purpose.

2. Our Method

Using only a single photograph of an animal fur, we are able to generate several fur textures automatically. From an upper view of an actual animal fur (fig.1 (a)), brighter region tend to be outside of the hair, and darker region likely to be inside. According to our observation, the depth of each pixel on a fur image highly depends on its brightness. Then, to generate the shell textures, we decided to approximate the distance from the surface as a function of each pixel's brightness.

If the fur could be assumed to be a scattering medium, the light which entered perpendicularly from the surface of fur arrives at the bottom of fur with exponential decreasing. Therefore, by referring to the brightness of the input image, it is possible to estimate the depth of the fur. When we create the histogram of the brightness of the input picture, the brightness of the depth h from the surface is:

$$I = I_{max} \exp\left(-\sigma_t h\right) \tag{1}$$

And attenuation coefficient σ_t is:

$$\sigma_t = -\frac{1}{h_b} \log \frac{I_{max}}{I_{min}} \tag{2}$$

I_{max} and I_{min} are the maximum and minimum of the histogram, and h_b is the thickness of the fur. So, if we generate N textures for rendering, we draw points which brightness is more than p(n-1) and less than p(n) to the n^{th} texture (n=1,2,⋯,N), which exists in the depth $h = h_b \cdot (n/N)$ from surface, and the brightness p(n) is given by the following:

$$p(n) = I_{max} \exp\left(-\sigma_t h_b \frac{n}{N}\right) = I_{max} \left(\frac{I_{min}}{I_{max}}\right)^{\frac{n}{N}} \tag{3}$$

These processes can be performed collectively by GPU. So we can draw realistic fur seen in the photographed input image by using the textures generated automatically. In addition, it is certainly difficult to estimate the thickness of fur from a single image. However, we can adjust intervals between shell textures, so we can get several appearance of fur and choose appropriate output image.

3. Results

Figure 1 shows an input image (a), layered shell textures (b), and furry model (c) using our method. The frame rate for rendering these models are, 1,648.3 fps for the teapot (2,082 vtx.) and 138.0 fps for the bunny (34,832 vtx.) at 256 x 256 pixels. These are obtained from 2.66GHz Intel(R) Core(TM)2 Duo with NVIDIA GeForce GTX 285. Furthermore, compared with conventional shell texturing which requires 4,096 KB of memory, our method uses only 256 KB. As a result, we are able to synthesize realistic image of fur on arbitrary 3D objects from a single input image.

4. Conclusions

In this paper, we propose a method which generates shell textures automatically from a single image, and synthesize an animal fur appearance on arbitrary 3D objects. Using shell textures which are computed by our method, it is possible to render in real-time as well as conventional method.

This work suggests some tasks for future researches, such as corresponding to more complicated fur which has two colors like zebra.

References

J. Lengyel, E. Praun, A. Finkelstein, and H. Hoppe. Real-time fur over arbitrary surfaces. In Proc. I3D'01. pp.227-232. 2001.

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