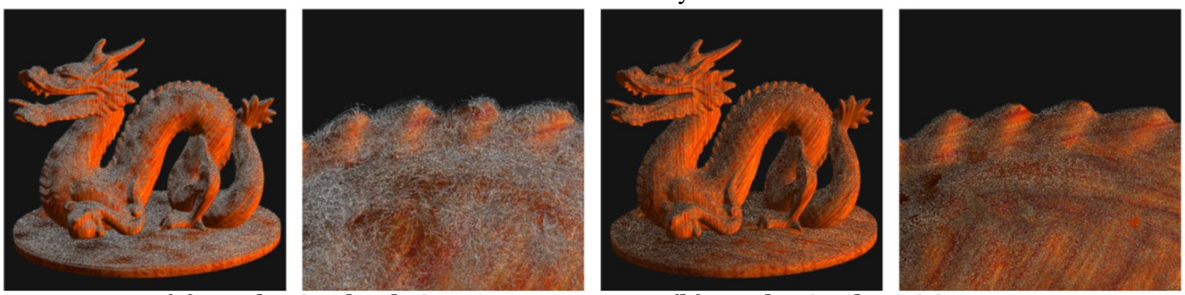
Real-Time Dust Rendering by Parametric Shell Texture Synthesis

Shohei ADACHI* Hiroaki UKAJI Takahiro KOSAKA Shigeo MORISHIMA
Waseda University



(a)Synthesized Fabric Dust **(b)Synthesized Fugitive Dust**

Figure 1 Synthesized Dust Variations by Parameter Control

1. Introduction

When we synthesize a realistic appearance of dust-covered object by CG, it is necessary to express a large number of fabric components of dust accurately with many short fibers, and as a result, this process is a time-consuming task. The dust amount prediction function suggested by Hsu [1995] proposed modeling and rendering techniques for dusty surfaces. These techniques only describe dust accumulation as a shading function, however, they cannot express the volume of dust on the surfaces. In this study, we present a novel method to model and render the appearance and volume of dust in real-time by using shell texturing. Each shell texture, which can express several components, is automatically generated in our procedural approach. Therefore, we can draw any arbitrary appearance of dust rapidly and interactively by solely controlling simple parameters.

2. Accumulated Dust Range

Our method uses shell texturing for rapid rendering of volumes. We have to define the distance between original polygon and top-lapped texture as the volume of accumulated dust. We determine this distance by using Hsu's function, the value of which is calculated by both normal and dust source directions. However, using only this function cannot express an uneven surface of actual accumulated dust caused by its components. To represent unevenness, we use Perlin noise which can generate in procedural approach and is utilized for rendering natural phenomenon. When we lap a rendering object with shell textures, we control rendering range of each texture by the brightness of Perlin noise texture. As a result, the variation of rendering range of each texture can represent an uneven feature of actual accumulated dust on the object surface.

3. Dust Texture Synthesis

For rendering components, we propose a new parametric synthesis of shell texture in procedural approach. We focus on a fibrous component whose appearance contributes to dust reality. To express such feature on a shell texture, we model each fiber with a point trajectory on 2D plane which direction is controlled by probability of movement map (PMmap) and 3 parameters. PMmap controls a direction of each point moving pixel by pixel by the probability defined for 8 pixels surrounding the current pixel. Probability x_i for direction angle θ is given by the following functions.

$$x_i = \begin{cases} 1 - \frac{\theta - i}{180} (0 \leq i < \theta) & \\ 1 - \frac{i-\theta}{180} (\theta \leq i < 180° + \theta) & (0 \leq \theta < 360°) \\ \frac{i-\theta}{180} (180° + \theta \leq i < 360°) & \end{cases} \quad (1)$$

x_i is quantized into 8 directions to generate PMmap. θ is arbitrary bending degree which is one of the additional 3 parameters. The other two parameters are movement time which controls the length of fiber and bending times which controls how many times fiber bends in unit fiber. By focusing on fibrous structure of real dust, we divide each fiber into 2 components such as slight movement part which has small angle not to affect a general direction of fiber and bending part which has great angle to affect general direction of fiber. Slight movement part is represented by movement depending on PMmap. Bending part is generated when probability of PMmap is recalculated by arbitrary bending degree and arbitrary bending times. Huge number of fibers are generated based on this procedure, then we can get a shell texture which can represent realistic appearance of accumulated dust fibers.

4. Results

Our synthesis results are shown in Figure 1. These results indicate that we are able to synthesize real fabric or fugitive dust appearances of arbitrary dust-covered objects only by modulating simple parameters. These results also show that our method succeeded to express detailed dust contents, which cannot be performed by previous works, especially even when we watch it in enlarged illustration.

The execution time of rendering Dragon model (550,968vtx) is 13.69[ms], and this is obtained from 2.9GHz Intel(R) Xeon(R) CPUX5647 with NVIDIA Quadro 4000. Using our method, it is possible to render dusty objects rapidly in real-time as well as original shell texturing.

5. Conclusions

In this paper, we propose a method for real-time rendering of realistic dust-covered object by focusing on the dust components. In our method, the process for acquiring each texture is automatic and procedural, therefore, we achieved several appearances of dust can be synthesized only by controlling simple parameters.

This work suggests some tasks for future researches, such as detecting and adjusting each parameter for real captured dust appearance.

Reference

HSU,S.C.,AND WONG,T. T. 1995. Simulating Dust Accumulation. IEEE Computer Graphics and Applications,vol. 15, 18-22.

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