Growing Fitted Textures

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Introduction

Adding texture to the surface of a polygonal model can profoundly enhance its visual richness. Given a texture pattern and a surface model, the historical challenge has been to determine how to apply the pattern to the surface in an appropriate manner, minimizing the visual impact of seams and projective distortion while orienting the pattern so that it flows over the shape in a desirable way.

In this talk, we address the problem of how to seamlessly and without repetition artifacts or visible projective distortion cover the surface of a polygonally-defined model with a texture pattern derived from an acquired 2D image such that the dominant orientation of the pattern will everywhere follow the surface shape in an aesthetically pleasing way. Specifically, we propose an efficient, automatic method for synthesizing, from a small sample swatch, patches of perceptually similar texture in which the pattern orientation may locally follow a specified vector field, such as the principal directions of curvature, at a per-pixel level, and in which the continuity of large and small scale features of the pattern is generally preserved across adjacent patches

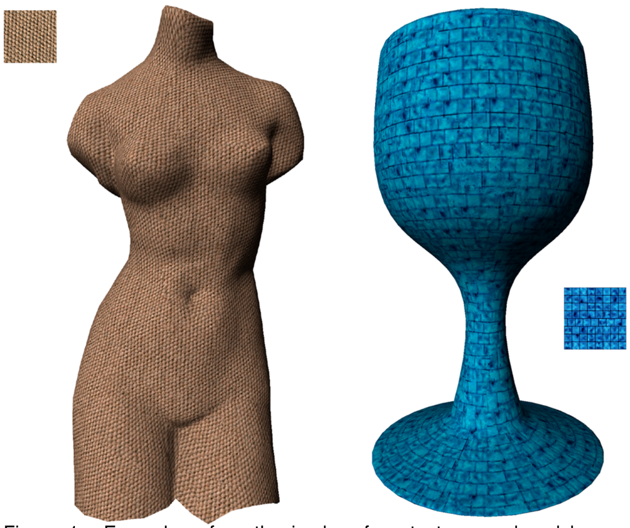

Figure 1: Examples of synthesized surface texture produced by our method. No manual intervention of any kind was employed. The textures were grown following a vector field locally defined by the projection of (0,1,0) onto the tangent plane at each point. The entire process required 12 minutes for the Venus and 20 minutes for the goblet.

Proposed Method

The method that we propose has the advantages of being essentially automatic (requiring no manual intervention), reasonably efficient, fairly straightforward to implement, and applicable across a wide variety of texture types and models. In addition, the resulting textured objects can be easily displayed at interactive frame rates using a conventional renderer on a standard PC with texture mapping hardware.

Our technique consists of the following main steps:

- Partition the polygons of the model into contiguous patches, as nearly planar as reasonably possible.
- Compute a vector field over the object, or read a pre-defined field from a file.
- Synthesize the texture pattern over each patch, using an efficient, orientation-adaptive variation of the non-parametric sampling method proposed by Efros and Leung [1].

The constant direction field used for fig. 1 produces good results in most obvious cases. Of greater intrinsic interest to our ongoing research is the possibility of applying an oriented texture pattern to the surface of an object such that it is everywhere aligned with the principal directions of curvature. Recent results in vision research support the idea that the principal directions play an important role in surface shape understanding.

Applications and Future Work

There are many promising applications for this system and many directions for future work. One of the most interesting of these is multi-texturing. On a per-pixel basis it is possible to change not only the direction of the synthesized texture but even the texture itself according to any arbitrary function. This multi-texturing method has the potential

Figure 2: The orientation of a directed pattern over a curved surface can influence our perception of the surface's 3D shape. On the left, the bricks are oriented in the direction of least signed normal curvature, and on the right they are oriented in the same constant "up" direction used for the models in figure 1.

to be useful for important applications in scientific visualization, for example in encoding a scalar distribution using texture type variations across an arbitrary domain in 2D or 3D. Other direction fields, such as gradient descent, hold promise for different applications, such as non-photorealistic rendering of terrain models (esp. in the case when it is desired to see through the surface). The methods that we have proposed can also be used for the visualization of scientifically computed vector fields over surfaces.

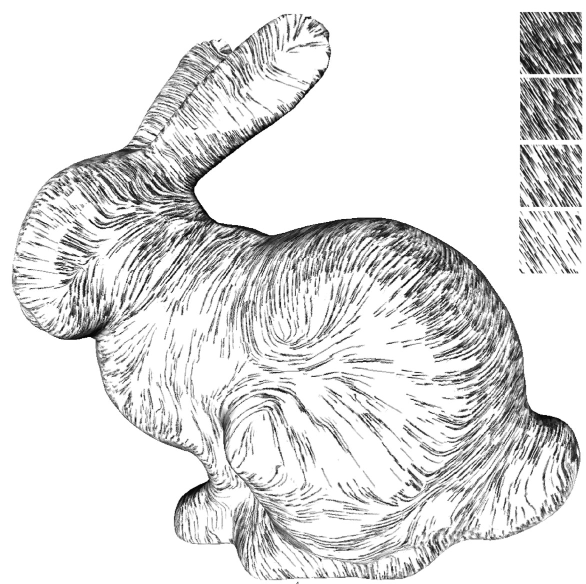

Figure 3: Multiple textures, indexed by illumination, applied to an automatically-defined smooth vector field approximating the first principal directions over the Stanford bunny.

References

A. Efros and T. Leung. Texture Synthesis by Non-Parametric Sampling, *Proc. International Conference on Computer Vision*, vol. 2, 1999, pp. 1033 -1038.