A Compact Model for Viewpoint Dependent Texture Synthesis

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Abstract. A texture synthesis method is presented that generates similar texture from an example image. It is based on the emulation of simple but rather carefully chosen image intensity statistics. The resulting texture models are compact and no longer require the example image from which they were derived. They make explicit some structural aspects of the textures and the modeling allows knitting together different textures with convincingly looking transition zones. As textures are seldom flat, it is important to also model 3D effects when textures change under changing viewpoint. The simulation of such changes is supported by the model, assuming examples for the different viewpoints are given.

1 Introduction

Increasingly, the computer vision and graphics communities turn toward the 3D reconstruction of large scenes. Not all parts of such scenes are equally interesting. An architectural highlight like a monument may be surrounded by streets with hundreds of normal houses. An archaeological site may contain interesting ruins that are dispersed in the landscape. Realistic visualization nevertheless imposes that the “less interesting” parts are displayed at the same resolution as the interesting ones. The synthesis of realistic textures can be part of the solution. Brick walls, grass, rocks, sand, concrete, vegetation, … can be emulated based on a compact model of these textures.

Several powerful texture synthesis methods have been proposed over the last couple of years [3, 4, 7, 11, 15, 19]. The realism of synthesized textures has gone up dramatically. With this paper we hope to contribute in a number of respects:

- *The texture* models *are very compact, yielding excellent compression.* In contrast to several recent methods, the model doesn’t contain an example image of the texture.
- *No verbatim repetitions of parts in stochastic textures.* There is no copying of patterns from the example image involved.
- *Perceptually convincing transitions where textures meet*. Seams between similar or

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different textures can be eliminated through the similar procedures as those used for texture synthesis.

- *Fast and compact inclusion of 3D effects.* The very existence of texture is usually due to the fact that the surface is not really flat. Hence, changing viewpoint entails more than simple foreshortening, although this is common practice in texture mapping. Effects like self-occlusion and different changes in the angle between the normals and the viewing directions are not taken into account through foreshortening. Our model can be adapted quickly to include these effects.

2 Clique Selection

Our approach extracts statistical properties from an example texture, which are then combined into a texture model. From this model more of the same texture is generated, i.e., textures that have similar statistics. Such texture synthesis methods differ in the properties that they extract and the algorithms to generate images with the prescribed statistics. The following sections describe these aspects for our approach.

2.1 Extracted Statistical Properties

The method extracts only first- and second-order statistics. This is in line with Julesz's observation that first and second-order statistics govern to a large extent our perception of textures. Yet, Julesz also demonstrated that third and higher order statistics couldn't be neglected just like that, mainly because of figural patterns that are not preserved [12]. As we will demonstrate, quite a broad range of textures can be synthesized nevertheless and in fact higher-order statistics can be included in the model, at the expense of computation time.

The first order statistics are characterized through the intensity histogram $f(q)$, where q is intensity.

The second-order statistics draw upon the cooccurrence principle: for point pairs at fixed relative positions the intensities are compared. The point pairs are called *cliques* and pairs with the same relative positions (translation invariance) form a *clique type* (Fig. 1). Individual cliques of type will be denoted as .

Cliques of the same type

Cliques of different types

Fig. 1. Cliques and clique types.