Composite Texture Descriptions

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Abstract. Textures can often more easily be described as a composition of subtextures than as a single texture. The paper proposes a way to model and synthesize such “composite textures”, where the layout of the different subtextures is itself modeled as a texture, which can be generated automatically. Examples are shown for building materials with an intricate structure and for the automatic creation of landscape textures. First, a model of the composite texture is generated. This procedure comprises manual or unsupervised texture segmentation to learn the spatial layout of the composite texture and the extraction of models for each of the subtextures. Synthesis of a composite texture includes the generation of a layout texture, which is subsequently filled in with the appropriate subtextures. This scheme is refined further by also including interactions between neighboring subtextures.

1 Composite Textures, Divide, and Conquer

Natural textures can be of a very high complexity, which renders them difficult to emulate by texture synthesis methods. Many of such textures consist of patches, which in turn contain patterns of their own. Good examples are the textures of building materials like marbles or limestones, or the textures of different landscape types. A countryside texture could, e.g. be a mixture of meadows and forests. We will refer to such textures as composite textures. Whereas the patterns within the patches may already be homogeneous enough to be modeled and synthesized successfully with existing techniques, modeling and synthesizing the mixture directly tends to be less effective. It therefore stands to reason to divide the synthesis of composite textures into several steps:

1. Segment (by hand or otherwise) example image(s) of the composite texture to be modeled, where each class is given its own label.
2. Consider the resulting label map (with labels assigned to all pixels) as a texture and extract a model for it.
3. Also extract models for the textures corresponding to the different labels (i.e. the different classes/segments).
4. Generate a synthetic label map, based on the model of step 2.
5. Fill in the segments generated under step 4 with textures according to their labels, based on the models of step 3.
This scheme tallies with ideas about “macrotexures” vs. “microtexures” that have emerged as soon as texture research started in computer vision. The label map can be considered a macrotexure, whereas the textures within the segments of constant label values would be microtexures. In this paper, we will refer to the macrotexures as “label textures”, and to the microtexures as “subtextures”.

Although such ideas have been around for quite a while, it seems that so far such hierarchical approach has not really been implemented for textures of a strong stochastic nature. When ideas about hierarchical analysis are used, it is usually in the context of multi-resolution schemes, which have contributed greatly to the state-of-the-art in texture synthesis (see e.g. [2, 7] as seminal examples). Contributions that come closest to the work presented here have used label textures that were hand-drawn by the user and the corresponding textures were then filled in with textures either by “smart copying” from example [8] or by synthesis techniques [13].

The composite texture approach as just described does not include mutual influences between the subtextures. It is not exceptional that the subtextures are not completely stationary within their domains. In particular, regularly a kind of transition zone is found near their boundaries. These changes may well depend on the texture on the other side of the boundary. Later in the paper we will modify the composite texture scheme to include such effects.

The remainder of the paper is organized as follows. Section 2 describes the texture synthesis approach used to generate the label textures and the subtextures. Section 3 shows some results for the synthesis of composite textures. Section 4 describes the inclusion of subtexture interactions (nonstationary aspects). Section 5 concludes the paper.

2 Image-Based Texture Synthesis

This section describes the approach that we use to synthesize the textures, i.e. both the label textures and the subtextures. More information about this texture modeling and synthesis approach can be found in [13]. It follows the cooccurrence paradigm in that texture is synthesized as to mimic the pairwise statistics of the example texture. This means that the joint probabilities of the intensities at pixel pairs with a fixed relative position are approximated. Such pairs will be referred to as cliques, and pairs of the same type (same relative position between the pixels) as clique types. This is illustrated in Fig. 1.

![Fig. 1. Dots represent pixels. Pixels connected by lines represent cliques. Left: cliques of the same type, right: cliques of different types.](image)

The texture model consists of statistics for a selected set of clique types. Clique type selection follows an iterative approach, where clique types are added one by one to the texture model, a texture synthesized based on the model is each time updated.