Journal of Fiber Bioengineering and Informatics 8:3 (2015) 433–441
doi:10.3993/jfbim00140

Texture Synthesis Based on Vector Field and Application in Textile and Clothing*

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Abstract

Texture is indispensable in image-based rendering. In order to obtain realistic and aesthetic texture, a simple and effective texture synthesis method based on vector field is presented in this paper. A sufficient large, progressively-variant, aperiodic texture can be generated from a small texture sample based on the proposed method. The main contributions in this method are anisometric synthesis and appearance control. Anisometric synthesis is attained by using an expanded sample structure called the warping image stack, together with a quadrant searching step and a continuity matching approach. Appearance control is achieved by associating each partition of the texture to a certain guiding vector, which arranges the partition to have corresponding local rotation and scaling. The experiments show that our method can produce textures with natural and flexible effect.

Keywords: Texture Synthesis; Vector Field; Appearance Control

1 Introduction

Texture synthesis technique plays an active role in several fields, such as image processing and 3D surface decorating. Specifically, in the jacquard CAD system, since the diversity of clothing styles lead to a large demand for variant textures, it is very meaningful to synthesize novel views from sample textures captured in the real world instead of recreating the entire physical world from scratch.

Most approaches about sample-based texture synthesis focus on how to eliminate the seams, while ignoring the importance of distinctive appearance of texture. In order to meet the requirement of application, texture design in jacquard CAD is required with complex structure and flexible appearance. From the simulation point of view, the real world textures are irregular, such as animal skin patterns are often with a variety of vortexes. On the other hand, from the artistic design point of view, the appearance of flexible design provides a wider space for designers to develop their creative. While for such purposes, a designer may have to spend extra time debugging parameters or using some image editor tools on the synthesized texture.

*Project supported by the Natural Science Foundation of China (No. 61379112, 61272192).
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In this paper, we specifically propose a new texture synthesis method based on vector field. According to the properties of vector field, the texture synthesis performances of irregular, fluency and so on can be obtained sufficient. The main objectives and contributions are in two points: anisometric texture synthesis and intuitive user control. The original sample texture can be extended to a series of transformed texture samples, which contain multi-scale warping information. The connection of texture tile and guiding vector ensures the appearance of texture to be anisometric, smooth and controllable. This method can be used in the textile image synthesis and 3D garment rendering. The experiments show that the synthesis effects are natural and flexible.

2 Related Work

2.1 Texture Synthesis

Texture synthesis algorithms build on a long sequences of early papers, as such techniques are easy to use and capable of producing results without unnatural artifacts or periodicity. Various fields like game engines and feature animations have put it in to practical [1]. Most sample-based approaches are based on the Markov Random Field theory, modeling a texture as a realization of a local and stationary random process. According to the basic unit of treatment, these methods can be divided into pixel-based, patch-based, or more generally, optimization-based. The traditional pixel-based approach is to synthesize image in scan-line order, and compare synthesized neighborhoods to search the best matching pixel [2]. The improvement methods include hierarchical synthesis [3], coherent synthesis [4], and order-independent synthesis [5]. These methods are often perceived as inherently limited due to narrow neighborhoods and lack of global optimization. Sylvain Lefebvre [6, 7] presented a high quality result with controllable aesthetic effect in real-time based on appearance space. However, the size of its synthesis result is fixed to some specific values, and multi-resolution may arise in different texture regions. Instead of synthesizing in pixel, patch-based approaches take patch as basic synthesis unit. Efros [8] proposed a patch-based method with fixed block size and used image quilting to eliminate the seams. Inspired by image quilting, Kawatra [9] and Cohen [10] optimized the seam problem and extend block size to arbitrary, while these improved algorithms are relatively time consuming and are not suitable for synthesizing large scale image. Extensions to perform texture synthesis on surfaces by forming seamless texture across atlas charts can be found in [11, 12]. Recently, more information about texture synthesis are reported [13, 14].

2.2 Vector Field

Vector fields arise from experiments, measurements and simulations in many scientific and engineering disciplines. It usually be used as an important analysis structure to understand underlying nature of the processes exhibiting a particular field or to be able to predict the system behavior in the real world. In a flexible and intuitive texturing system, users need to control the orientation and sizing of texture on surface. Such controls are often achieved by designing a vector field prescribing one of the axes of the local coordinate frames. Some vector field design tools use interpolation from scattered user-specified directions [15, 16], and others also allow singularity control [17, 18]. Zhang [17] proposed a method to use geodesic polar maps and parallel transport to create radial basis functions. Fisher [18] employed the tools from discrete exterior calculus,