A Comprehensive study of Texture Synthesis Techniques

Mr. Vishal Patel
Computer Engineering. Dept
Parul Institute of Engg. & Tech.
Vadodara, Gujarat, India.
ivishalce37@gmail.com

Mr. Satish Kachhadiya
Computer Engineering. Dept
Parul Institute of Engg. & Tech.
Vadodara, Gujarat, India.
satishkachhadiya@gmail.com

Mr. Shailendra Mishra
Computer Engineering. Dept
Parul Institute of Technology.
Vadodara, Gujarat, India.
shailendrabemtech@gmail.com

***Abstract*- Texture synthesis is a modern technology which grows rapidly in recent ten years. Texture synthesis is a core process of computer graphics applications, which can enhance the realistic rendering greatly. With the rapidly increasing demands of realistic rendering, single texture synthesis cannot meet the needs. Multi-exemplars synthesis is a challenging research topic to increase the richness of texture details. We survey the algorithms for synthesizing textures that have proposed over the past two decades. A variety of algorithms associated with synthesized textures are given. The goal is to further understand textures, to provide the methodology needed to generate various textures in other studies, and to instigate pursuing better models for synthesizing more interesting textures.**

***Keywords*--- Texture synthesis, Multi-exemplars texture synthesis, Tile-Based Algorithm, Exemplar-relation Graph.**

I. INTRODUCTION

Texture synthesis has become hot research in Photorealistic Rendering (PR), particularly in the areas of Computer Graphics (CG), Computer Virtual Reality (CVR) and Image Processing (IP) since its inception. It is an efficient way to produce texture and is widely used in such application fields as computer graphics, computer game, image processing, virtual reality, and computer vision, etc[1]. Recently, texture synthesis technology has gained great breakthrough and researchers pay more and more attention to it. Textures can describe a wide variety of natural phenomena, thus greatly enhancing the realistic rendering. Most texture images are too small to be used, for there exists limits in capturing textures. Directly enlarging the images and mapping them to the surface of objects will induce bad visual effects, such as seams and unrealistic aliasing.

A way to solve those problems is using texture synthesis. Textures have been traditionally classified as either regular (consisting of repeated texels) or stochastic (without explicit texels). However, almost all real-world textures lie somewhere in between these two extremes and should be captured with a single model. Texture synthesis technology has experienced three stages: Texture Mapping (TM), procedural Texture Synthesis (PTS) and Texture Synthesis from Samples (TSFS).

In reality, there are a large number of images, which have different structures at different scales, such as satellite or microscope images. Texture has this sort of multi-scale property we call multi-scale texture. Multi-scale texture synthesis aim to synthesize a texture that could preserve the multi-scale property of several input exemplar textures.

Paper is organized as follow: In section 2, we have briefly describe different methods (algorithms) of Texture Synthesis in which we have reviewed some recent research paper for texture synthesis Section 3 contains discussion, Section 4 contains conclusion and future studies and finally in section 5 contain references .

II.TEXTURE SYNTHESIS TECHNIQUES

Here we have briefly explained different techniques available for Texture Synthesis like Fast texture synthesis using Feature matching [1], Optimization-based Multi-scale Texture Synthesis [2] , An Improved Example-based Texture Synthesis Algorithm[3], Depth Image Based Rendering With Advanced Texture Synthesis[4], Texture Synthesis by Non-Parametric sampling[5],Sample-Based synthesis of Illustrative Patterns.

A. *Fast texture synthesis using feature matching:*

A novel tile-based algorithm is proposed to achieve real-time synthesis of structural texture. The Algorithm operates by the joint use of tiling and feature matching. Firstly, quantitative evaluation of texture regularity is introduced to classify different texture. Secondly, a new geometry-color measure which evaluates texture similarity from both geometry and color distance is brought forward to pick the best sample pattern from input texture. Thirdly, in contrast to traditional tile-based algorithms that choose the cutting curve by color assess, they uses feature matching and feature deformation to reduce the appearance of conspicuous seams and dislocated features.

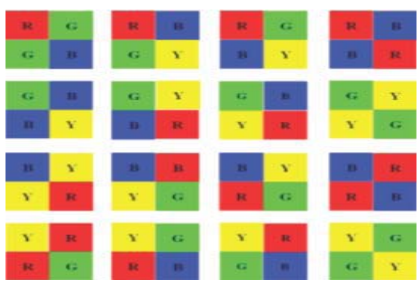


Figure 1: Set of 16 w-tile

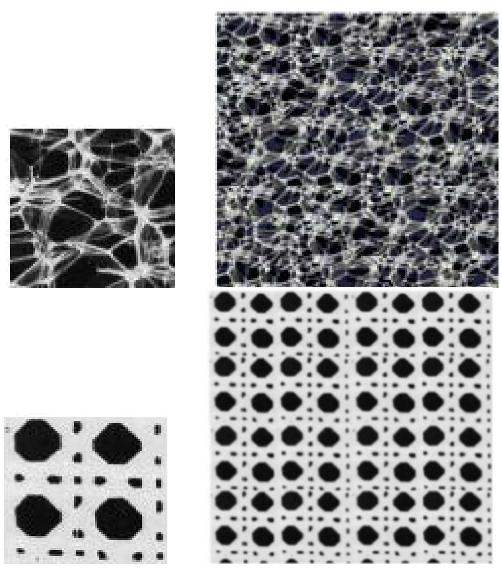
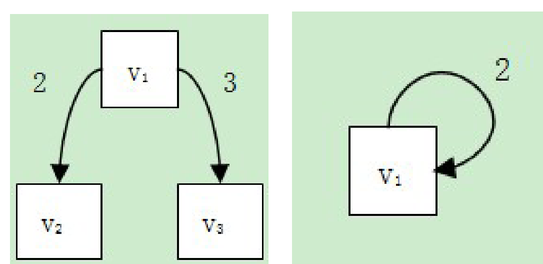


Figure 2: Results for stochastic texture Results for structural texture Synthesis

B. *Fast Optimization-based Multi-scale Texture Synthesis*

Multi-scale texture synthesis is a rising research in recent years. There are two shortcomings: First, the exemplar design is very difficult; Second, Multi-scale texture synthesis uses pixel matching. Pixel matching cannot capture the big structure information of the texture and it requires significant resources. A new multi-scale texture synthesis algorithm based optimization was proposed. The algorithm of this paper employs exemplar relation graph to describe the relationship of input exemplar textures, and up sample, jitter step to add richness of the output texture, energy optimization step to guarantee the rationality of the patch matching Exemplar-relation Graph.

In this paper, they introduced the exemplar-relation graph defined in [8], and adapted it to their algorithm. The exemplar-relation graph (V, E), is a reflexive, directed, weighted graph. Vertex set V={v1,v2,v3, }, each element in V is an exemplar. E, denotes similarity relations between Exemplars. The root, v1 serves as the coarsest-level starting point for synthesis. The weight of edge denotes the scale relationship between their vertexes.



(a) (b)

Figure 3(a)Exemplar-relation graph(V1,E1) (b)One vertex exemplar-relation graph.

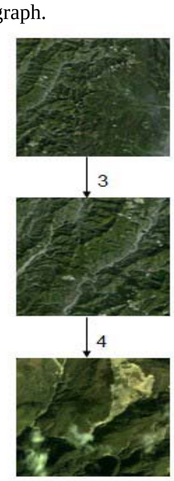


Figure 4(a) Exemplar-relation graph

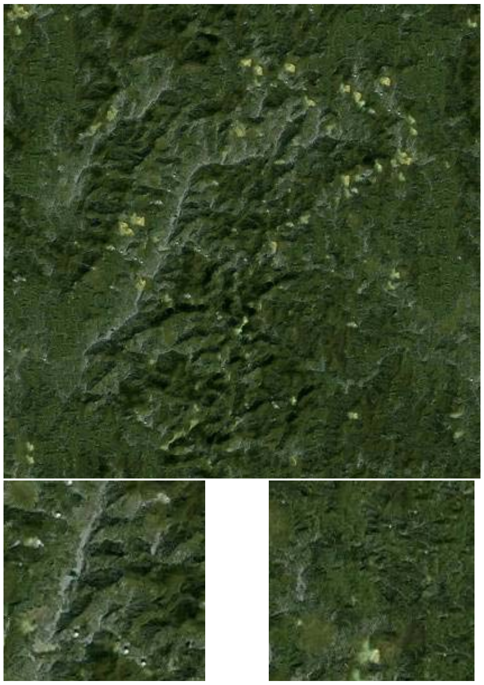


Figure 4(b) The synthesis result

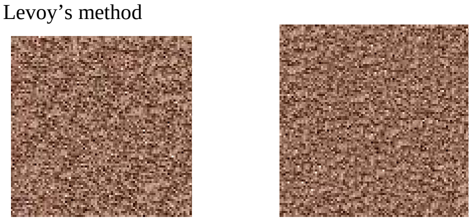
C. *Fast An Improved Example-based Texture Synthesis Algorithm*

An improved example based texture synthesis algorithm is proposed. The basic idea is from the famous texture synthesis algorithm of WL00[6].They make two improvements to the original WL00 algorithm: the first one is to automatically select the proper size of the neighborhood; and the second is to synthesize three other than one pixel each time to accelerate the procedure. With these two improvements, texture synthesis can be done more conveniently and more efficiently without decrease of synthesis quality.

WL00 Algorithm

The basic algorithm: The neighborhood used in the WL00 algorithm is L shaped, as shown in figure 1. According to their method, the output is synthesized in a scan line order instead of the inside-out fashion. The L-shaped neighborhood is generally with the size of N × (N +1)/2 , where N is commonly chosen to be an odd number for programming convenience.

Figure 5. Neighborhood N (p) a pixel p defined in the Wei and Levoy's method

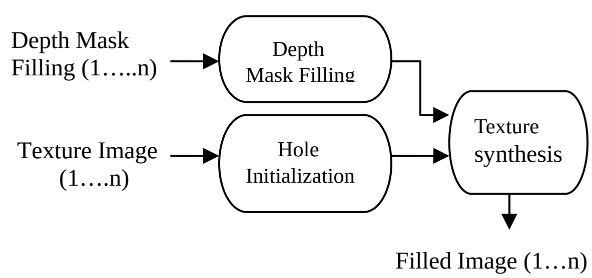


(a) (b)

5.(a) Synthesized texture with WL00 5.(b) Synthesized texture with the proposed method

D. *Depth Image Based rendering with Advanced texture Synthesis*

In free viewpoint television or 3D video, depth image based rendering (DIBR) is used to generate virtual views based on a textured image and its associated depth information. In doing so, image regions which are occluded in the original view may become visible in the virtual image. One of the main challenges in DIBR is to extrapolate known textures into the disoccluded area without inserting subjective annoyance. In this paper, a new hole filling approach for DIBR using texture synthesis is presented. The approach works for large baselines and the rendering results are visually consistent. A robust initialization is used to obtain an estimate of the disoccluded area. Subsequently, a refinement step based on patch-based texture synthesis is applied. Overall, the proposed algorithm gives both subjective and objective gains.
Block diagram of the proposed approach. First, disocclusions in the DM are filled.
Then the holes are initialized and refined with texture synthesis.



E. *Texture Synthesis by Non-parametric Sampling*

A non-parametric method for texture synthesis is proposed. The texture synthesis process grows a new image outward from an initial seed, one pixel at a time. A Markov random field model is assumed, and the conditional distribution of a pixel given all its neighbors synthesized so far is estimated by querying the sample image and finding all similar neighborhoods. The degree of randomness is controlled by a single perceptually intuitive parameter.

Algorithm: In this work we model texture as a Markov Random Field (MRF). That is, we assume that the probability distribution of brightness values for a pixel given the brightness values of its spatial neighborhood is independent of the rest of the image. The neighborhood of a pixel is modeled as a square window around that pixel. The size of the window is a free parameter that specifies how stochastic the user believes this texture to be.

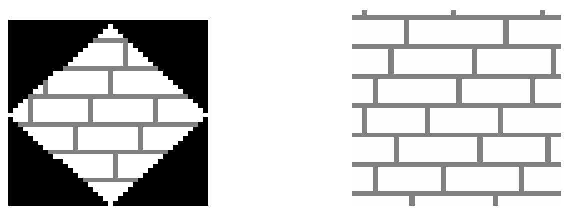


Figure6. Algorithm Overview. Given a sample texture image (left), a new image is being synthesized one pixel at a time (right).

To synthesize a pixel, the algorithm first finds all neighborhoods in the sample image (boxes on the left) that are similar to the pixel's neighborhood (box on the right) and then randomly chooses one neighborhood and takes its center to be the newly synthesized pixel.

F. *Texture Sample-Based Synthesis of Illustrative Patterns*

They have presented a simple example-based method for synthesis of patterns defined as 2D collection of vector elements. Their solution is inspired on previous work, both on patch-based texture synthesis and vectorial arrangement synthesis. This method can produce good results from regular and irregular distribution of elements in the samples, being near regular patterns the most difficult to deal with. They plan to extend the model for synthesis over 3D arbitrary surfaces, and improve the direct synthesis of illustrative patterns over 3D models taking into account tonal value maps at different scales. Other areas of future work will include a formal qualitative evaluation of the results by illustrators.

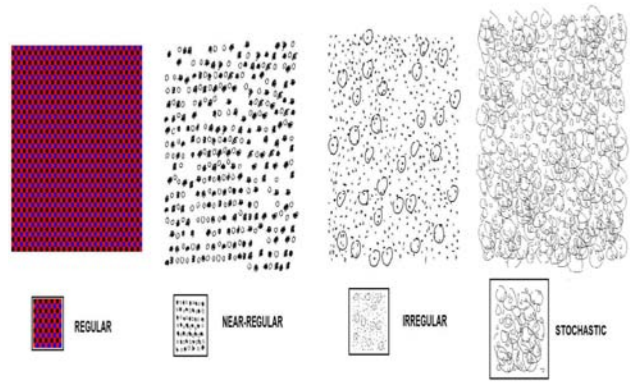


Figure 7. Illustrative patterns synthesized by simple example-based method.

I.DISCUSSION

Topic Name	**Algorithm Used**	**Description**
Texture synthesis by Non parametric sampling	Markov random field algorithm	Preserve as much local structure as possible and produces good results for a wide variety of synthetic and real-world textures.
Fast texture synthesis using feature matching	W-tile algorithm	-Quantitative evaluation of texture regularity is introduced -Geometry color measure are used to pick the best sample pattern From input.
Optimization-based Multi-scale Texture Synthesis	Optimization-based multi-scale texture synthesis algorithm	-Exemplar relation graph to describe the relationship of input exemplar textures, and up sample, jitter step to add richness of the output texture
An Improved Example-based Texture Synthesis Algorithm	WL00 algorithm	-Automatically determine the neighborhood size during the neighborhood match process -Algo.is effective and efficient
Sample-Based synthesis of Illustrative Patterns	Simple example-based method	Produce good results from regular and irregular distribution of

		elements in the samples

IV. CONCLUSION AND FUTURE WORK

We have reviewed several mathematical models for texture synthesis. Algorithms for texture synthesis based on models associated with generated textures have also been given. Each model seems to synthesize visually different textures. It is important for researchers and developers to realize that visual features of the textures can play a very significant role in enhancing the quality of the synthesis results. In the near future, we think that techniques which are designed with the main purpose of increasing the synthesis quality of texture examples with special visual effects will be developed. With the rapidly increasing demands of realistic rendering, single texture synthesis cannot meet the needs. We try to use exemplar graph to realize Multi-exemplars texture synthesis under user's control.

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