Morphological Texture Synthesis Algorithm Using Pixel and Patch Based Approach

G. Venkata Rami Reddy, Dr. V.VijayaKumar, Dr. M. Anji Reddy

Abstract — The present paper involves a new method for synthesizing textures based on morphology. The present paper uses a combination of pixel and patch-based methods using morphological region filling methods to synthesize textures. The present paper initially identifies number of regions and selects the seed points in the regions using Hit-miss-transform (HMT). The present paper initially detects the regions based on morphological contour segmentation approach, which preserves the well connectivity between regions. To make these thin contours more visible morphological thickening is performed, which preserves the original shape. The target regions are filled with patches from the source region possessing similar textures by using the seed point reference. Experimental results on various textures show that the present system can efficiently handle different textures especially with large regions. To test the efficacy of the proposed method PSNR values are calculated and compared with the existing methods. The experimental results clearly indicate the proposed method outperforms the existing method.

Keywords: pixel and patch-based linear searching, Hit-Miss Transform, region filling.

1 Introduction

One of the very important research areas in computer graphics and computer vision over years is the texture synthesis. Texture refers to the class of imagery that can be categorized as a portion of an infinite pattern consisting of stochastically repeating elements. The key behind texture synthesis techniques is the inherent repeatability present in textures. These techniques generate output textures that are larger in size than the input sample but perceptually similar to it.

Texture synthesis techniques can be broadly divided into local region-growing methods and global optimization-based methods. In local methods the texture grow one pixel or patch at a time with the goal of maintaining coherence with nearby pixels in the growth region [1,2,3]. This leads to inconsistencies, in these approaches, because the small errors in the synthesized texture can accumulate over large distances. The disadvantage of the local methods is they consume lot of time and hence they do not sufficiently meet real-time applications. The global methods evolve the entire texture as a whole, based on some criteria for evaluating similarity with the input.

Most existing global approaches either model complex formulations that are difficult to optimize or model an only pixel-to-pixel interaction which leads to difficulties in capturing large scale structures of the texture. [4,5,6,7]. Many researchers used the pyramid structure [4], tree-based accelerate mechanism [8] and multi-resolution approach [9,10, 11] to improve the efficiency of texture synthesis.

The Pixel-based synthesis algorithms are based on spatial neighborhood methods which match across different frequency bands [1, 2, 12, 13] and they grow an output texture pixel by pixel. These approaches are fit for stochastic textures, but usually fail on textures with more coherent structures. One of the methods which are generally more successful on synthesizing structural textures is path based methods [3, 14, 15, 16] which copy selected source regions into the output instead of single pixels. Some intermediate techniques [11, 17] between pixel and patch-based methods have also been presented, which somewhat combine the advantages of both.

2 Morphological Texture Synthesis (MTS) Algorithm

The entire algorithm is explaned below.

Let Iin be an example texture sample as the input. Initialize the texture synthesis unit Iout to be a square block of user-specified size. The complete process to synthesis a new texture image Iout is given in thefollowing:

1. Take the original example image Iin, if the original image is color, converted into gray image.
2. First identify all the regions (R1, R2, R3, ….) of the image.
3. Identify seed pixel of each region using Hit-Miss Transform.
4. Extract contours of R1.
5. Apply morphological thickening operation of extracted contour (R1) with suitable structuring element and the result is stored in T1.
6. Extract contours of T1.
7. If the number of pixels in the contour of T1 is more than the number of pixels in contour of R1 then superimpose R1 with T1 else repeat step 5 using T1 with same structuring element and repeat step-7.
8. Take the selected seed pixel of the region R1; apply Region-fill by using patch matching algorithm of the superimposed image i.e RT1.
9. Resulting RT1 image is placed into the synthesized image Iout.
10. Repeat steps (4)-(9) till the whole image I_{out} are synthesized.

2.2 Region Identification Algorithm

To detect the regions a reference image called a segment map is introduced, in the present approach, to make a correct selection from the candidate pool, which corresponds to a coarse segmentation of the original image. As an initialization step, the whole image is segmented into several separate regions according to the texture similarity. The present paper adopted contours to achieve this segmentation. The contour based segmentation preserves the well connectivity between regions. This is very use full for patch filling. The entire process is represented by the equation 5. In the equation 5 the image is denoted by R, N represents the number of regions with each region as Ri, by the following Eqn. (1)

$$R = \bigcup_{i=1}^{N} R_i \quad \text{and} \quad R_i \cap R_j = \emptyset \quad (1 \le i,j \le N) \tag{1}$$

2.3 Thickening

The Contour segmentation segments the original image with thin contours. To make thin contours as more visible thickening operation is performed using morphology. The thickened image preserves the original shape. The thickening operation is calculated by translating the origin of the structuring element to each possible pixel position in the image, and at each such position comparing it with the underlying image pixels. If the foreground and background pixels in the structuring element exactly match, with the foreground and background pixels in the image, then the image pixel underneath the origin of the structuring element is set to foreground (one). Otherwise it is left unchanged. Thickening is the morphological dual of thinning and defined by the following Eqn. (2).

$$A \odot B = A \cup (A \circledast B) \tag{2}$$

$A \odot B$ denotes thickening, thickening can be defined as a sequential operation as follows

$$A \odot \{B\} = ((\ldots ((A \odot B^1) \odot B^2)\ldots) \odot B^n)$$

In the fourth step to grow the size of the object contours are formed for the thickened image. .

2.4 Seed Pixel Identification using Hit-Miss Transform

The proposed method searches for a seed point of a region and in the second part finds all pixels in the image that are connected with the seed point and provide them with a mark which indicates that they have been taken into account. The present paper initiates a new approach for detecting seed point by using Hit-Miss Transform (HMT). The HMT is a fundamental Morphological Operation on binary images. Mathematical morphology is a well-founded non-linear theory of image processing [18, 19, 20, 21]. Its geometry-oriented nature provides an efficient framework for analyzing object shape characteristics such as size and connectivity, which are not easily accessed by linear approaches. Mathematical morphology is theoretically founded on set theory. It contributes a wide range of operators to image processing, based on a few simple mathematical concepts. The operators are particularly useful for the analysis of binary images, classification, synthesis, boundary detection, noise removal, image enhancement, and image segmentation.HMT is a basic tool for shape detection. Its main objective is to find the location(s) of the object of interest in a given image. The HMT uses a pair of contradicting SEs (A, B), and looks for all positions where A can be fitted within a figure X, and B within the background Xc, in other words The morphological HMT transform is defined by the following Eqn. (3)

$$A \circledast B = (A \ominus X) \cap [A^c \ominus (W - X)] \tag{3}$$

$A \circledast B$ - Denotes hit-or-miss transform
AΘ X- Denotes erosion transforms,
W- Denotes a small window

One can generalize the notation somewhat by letting B = (B1, B2), where B1 is the set formed from elements of B associated with an object and B2 is the set of elements of B associated with the corresponding background. From the preceding discussion, by considering B1 = X and B2 = (W-X), then the equation 3 becomes

$$A \circledast B = (A \ominus B_1) \cap (A^c \ominus B_2) \tag{4}$$

Thus, the set $A \circledast B$ contains all the points of A at which B1 is 'hit' and B2 is found a match in Ac i.e missing. By using the definition of set differences and the dual relationship between erosion and dilation the equation 4 can be written as

$$A \circledast B = (A \ominus B_1) - (A^c \oplus B_2) \tag{5}$$

However, equation 4 is considerably more intuitive. We refer to any of the preceding three equations as the morphological HMT.

The present paper utilized a structuring element B1 associated with objects and an element B2 associated with the background based on an assumption that two or more objects are distinct only if they form disjoint (disconnected) sets. This is guaranteed by requiring that each object have at least a one-pixel-thick background around it.. For this a one-pixel-thick background operation is required in the HMT, that's why equation 2 is adopted in the present paper for detection of seed points.

2.5 Patch Filling

The target region is filled with patches from the source region possessing similar texture by using seed point reference. The patches are selected from the linear searching of the seed point reference. Once the reference seed of the corresponding region is identified then it is filled with the corresponding region of the original texture image by using patch based algorithm. This process is repeated to fill all the regions. This process is similar to patch matching in texture synthesis. In the present approach matching patch is achieved by searching the sample of texture along seed point from the position of synthesized patch in the sample.

3 Results and Discussions

The proposed method is tested on several color and gray images, some of which are taken from other studies in the literature in order to make a comparison. The Fig.2 shows some texture synthesis results using the proposed algorithm. Proposed method works well for a wide range of textures. Table I show that the PSNR results of the proposed technique for selected textures. Table II compares the PSNR performance of the proposed method with the existing methods i.e., seeding

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texture synthesis algorithm [22], image quilting for texture synthesis [3] and Graph cut Textures [14].Table II clearly shows that the PSNR value of the proposed method is high when compared to the all other methods.

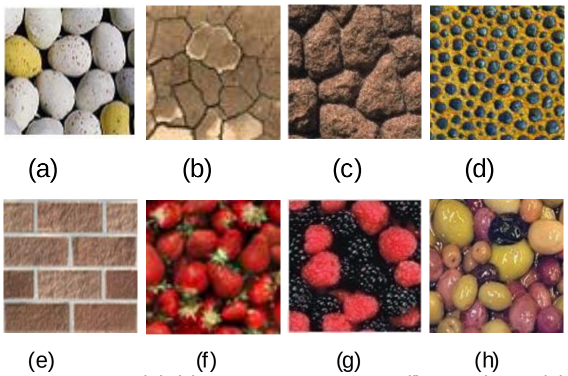

Fig.1 Input Textures: (a)-(e) are stone Textures, (f) strawberry (g) Litchie (h) Dates.

Fig.2 Synthesized Textures of above input images.

Table1: PSNR results for the proposed method

Texture Name	PSNR (dB) of Proposed Method
Stone-1	32.29
Stone-2	27.54
Stone-3	29.6.4
Stone-4	26.50
Stone-5	31.25
Strawberry	21.45
Litchie	32.44
Dates	35.19

Table2: PSNR results for the proposed and existing methods

	Proposed Method	Existing Methods		
Texture Name	PSNR (dB) of Proposed Method	Seeding Algorithm	Image Quilting	Graphcut
Stone-1	32.29	27.34	21.2	18.96
Stone-2	29.54	27.52	25.96	22.5
Stone-3	29.6.4	29.45	21.67	27.87
Stone-4	29.5	20.96	21.45	26.58
Stone-5	31.25	23.56	19.78	21.56
Strawberry	29.45	19.67	15.54	23.87
Litchie	32.44	24.43	21.46	22.8
Dates	35.19	28.5	25.6	26.7

As demonstrated in this document, the numbering for sections upper case Arabic numerals, then upper case Arabic numerals, separated by periods. Initial paragraphs after the section title are not indented. Only the initial, introductory paragraph has a drop cap.

4 Conclusions

The proposed approach integrates the pixel and patch based local searching methods using morphological approach. The present paper initiates a new approach for detecting seed point by using Hit-Miss Transform (HMT). The morphological seed identification is useful for selection of the regions and also easy searching of filling the corresponding regions. The present paper presents a new texture synthesis algorithm featured with a new search rule that searches matching patch using the idea of seed point. The main advantage of proposed algorithm is finding seeds are very fast, very simple and also filling by seeds of the region is fast. The method can effectively and efficiently handle large complex and stochastic regions. The proposed algorithm is particularly effective for structured textures. The experimental results indicate the efficacy of the proposed method over the other method.

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