Approaches for Texture Image Creation

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Abstract –**This article discusses two ways to create texture images - procedural (texture generation) and texture synthesis. The procedural approach is used to create images of natural phenomena such as terrain, fire, clouds, water, fog, vegetation for the purposes of computer graphics. Texture synthesis is applied when analyzing a small digital image we receive a larger one without visible repetitions and boundaries. The results of the generation and synthesis of the textures are applied.**

Keywords – **Texture image, Texture generation, Texture synthesis**

I. INTRODUCTION

An image texture is a set of metrics calculated in image processing designed to quantify the perceived texture of an image. Image texture gives us information about the spatial arrangement of color or intensities in an image or selected region of an image.

In 3D computer graphics, a texture is a digital image applied to the surface of a three-dimensional model by texture mapping to give the model a more realistic appearance.

In image processing, every digital image composed of repeated elements is called a "texture".

Texture can be arranged along a spectrum going from stochastic to regular.

Image textures can be artificially created or found in natural scenes captured in an image. Image textures are one way that can be used to help in segmentation or classification of images. To analyze an image texture in computer graphics, there are two ways to approach the issue: Structured Approach and Statistical Approach.

The image texture can be a photograph of a "real" texture or can be created by a procedural order.

II. PROCEDURAL TEXTURE GENERATION

Procedural techniques [1], [2] are code segments or algorithms that specify some characteristic of a computer-generated model or effect. Procedural texture does not use a scanned-in image to define the color values. Instead, it uses algorithms and mathematical functions to determine the color.

One of the most important features of procedural techniques is abstraction. In a procedural approach, rather than explicitly specifying and storing all the complex details of a scene or sequence, we abstract them into a procedure and evaluate that procedure when and where needed. This allows us to create inherent multiresolution models and textures that we can evaluate to the resolution needed.

We also gain the power of parametric control, allowing us to assign to a parameter a meaningful concept (e.g., a number that makes mountains rougher or smoother). This parametric control unburdens the user from the lowlevel control and specification of detail.

Procedural models also offer flexibility. Procedural techniques allow the inclusion in the model of any desired amount of physical accuracy. The designer may produce a wide range of effects, from accurately simulating natural laws to purely artistic effects.

One major defining characteristic of a procedural texture is that it is synthetic - generated from a program or model rather than just a digitized or painted image.

The advantages of a procedural texture over an image texture are as follows:

• A procedural representation is extremely compact. The size of a procedural texture is usually measured in kilobytes, while the size of a texture image is usually measured in megabytes. This is especially true for solid textures, since 3D texture images are extremely large. Nonetheless, some people have used tomographic X-ray scanners to obtain digitized volume images for use as solid textures.

• A procedural representation has no fixed resolution. In most cases it can provide a fully detailed texture no matter how closely you look at it (no matter how high the resolution).

• A procedural representation covers no fixed area. In other words, it is unlimited in extent and can cover an arbitrarily large area without seams and without unwanted repetition of the texture pattern.

• A procedural texture can be parameterized, so it can generate a class of related textures rather than being limited to one fixed texture image.

The disadvantages of a procedural texture as compared to an image texure are as follows:

• A procedural texture can be difficult to build and debug. Programming is often hard, and programming an implicit pattern description is especially hard in nontrivial cases.

• Evaluating a procedural texture can be slower than accessing a stored texture image. This is the classic time versus space trade-off.

• Aliasing can be a problem in procedural textures. Antialiasing can be tricky and is less likely to be taken care of automatically than it is in image-based texturing.

To generate irregular procedural textures, we need an irregular primitive function, usually called noise. This is a function that is apparently stochastic and will break up the monotony of patterns that would otherwise be too regular.

The obvious stochastic texture primitive is white noise, a source of random numbers, uniformly distributed with no correlation whatsoever between successive numbers.

Procedural texturing uses fractal noise extensively. The noise function simply computes a single value for every

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location in space. We can then use that value in literally thousands of interesting ways, such as perturbing an existing pattern spatially, mapping directly to a density or color, taking its derivative for bump mapping, or adding multiple scales of noise to make a fractal version. While there are infinitely many functions that can be computed from an input location, noise's random (but controlled) behavior gives a much more interesting appearance than simple gradients or mixtures of sines.

Below are shown the images (fig,1) procedurally generated with midpoint displacement procedure that can be used in terrain scenes, scenes with landscapes, clouds and meadows. The images (a) are created by a procedure and then the intensity of each point is used as a height for receiving 3D terrain (b). The images (c) are created with different color scheme and control parameter.

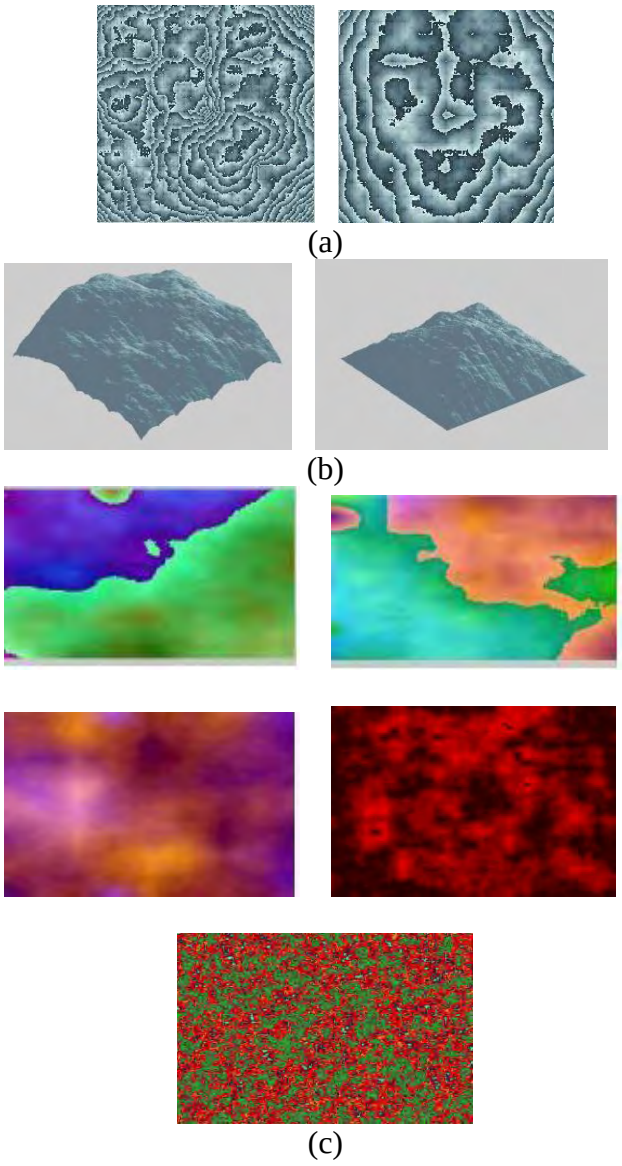


Fig.(1). Generated texture images by generalized stochastic subdivision (midpoint displacement procedure)

III. TEXTURE SYNTHESIS

The texture synthesis problem may be stated as follows: Given an input sample texture, synthesize a texture that is sufficiently different from the given sample texture, yet appears perceptually to be generated by the same underlying stochastic process.

Texture synthesis algorithms are intended to create an output image that meets the following requirements:

- The output should have the size given by the user.
- The output should be as similar as possible to the sample.
- The output should not have visible artifacts such as seams, blocks and misfitting edges.
- The output should not repeat, i. e. the same structures in the output image should not appear multiple places.

Like ithe most algorithms, texture synthesis should be efficient in computation time and in memory use.

Pyramid-Based Texture Synthesis

Pyramid-based texture synthesis [Heeger and Bergen] [3] is a very first `fast' algorithm that generates a new texture by matching certain statistics with the training sample. In the method, a texture is decomposed into pyramid-based representations, i.e. an analysis and a synthesis pyramids are constructed from the training and the output textures respectively.

Multi-resolution Sampling

Multi-resolution sampling [4], proposed by DeBonet, also constructs an analysis and a synthesis Guassian/Laplacian pyramids in texture synthesis. But it has two major improvements over the previous method. First, multi-resolution sampling extracts a set of more detailed and sophisticated image features by applying a filter bank onto each pyramid level. Second, multi-resolution sampling explicitly takes the joint occurrence of texture features across multiple pyramid levels into account, while the previous method processes each pyramid level separately.

Pixel-based Non-parametric Sampling

Pixel-based non-parametric sampling [5], [6], [7], constrains pixel sampling using a similarity metric defined with respect to a local neighbourhood system in an MRF (fig.2).

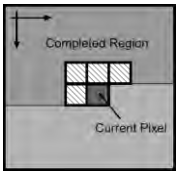


Fig.2. The `L'-shaped neighbourhood in a pixel-based non-parametric sampling (a 3X3 neighbourhood window in this case). Each square represents a pixel and the arrows indicate the synthesis is performed in a raster scanline order.

The method assumes an MGRF model of textures so that a pixel $i \in g$ only depends on the pixels in a local

neighbourhood $N_i \in g$. The distance between neighbourhoods N_i and N_j, e.g., the sum-of-square-difference (SSD), provides a metric of pixel similarity between i and j. To synthesise a pixel i, the algorithm searches for a pixel j from the training texture that minimises the distance between N_i and N_j, and then uses the value of pixel j for pixel i.

Block Sampling

Block sampling [8] is a natural extension to the previous pixel-based methods, which improves time efficiency of the synthesis by using image blocks as basic synthesis units. So, instead of pixel by pixel, block sampling synthesises a texture on a block by block basis (fig.3).

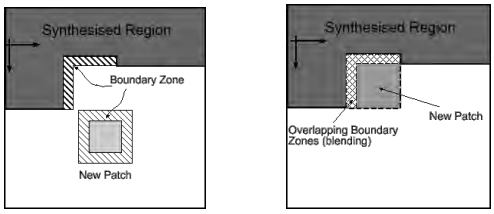


Fig. 3: Patch-based non-parametric sampling: (a) The boundary zones in a new and a already synthesised patches. (b) The overlapping boundary zones after a new patch is placed into the output texture. The arrows indicate the synthesis is performed in a scanline order.

Image Quilting

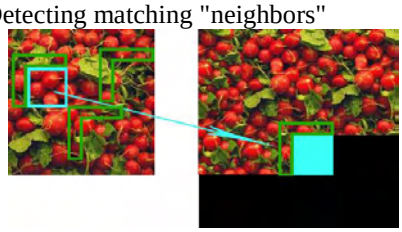
Image quilting [9,10] improves the patch-based non-parametric sampling by developing a more sophisticated technique to handle the boundary conditions between overlapped image patches. Instead of using the oversimplified blending technique, image quilting exploits a *minimum error boundary cut* to find an optimal boundary between two patches. An optimal cut defines an irregular path separating overlapping patches, so that each patch provides the synthetic texture only image signals on its side of the path.

Results of our algorithm based on block sampling procedure with image quilting (Fig. 4):

Step 1. Define patch that will be filled from the input image. It will be synthesized in step M

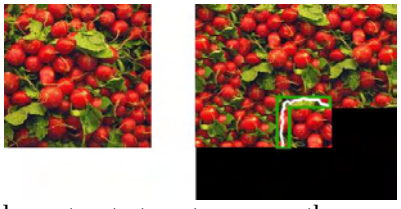
Step 2. Create a "neighbor" - an image formed around a patch.

Step 3. Detecting matching "neighbors"



Step 4. Selecting the best of all "neighbors"

Step 5. Copy selected "neighbor" and patch of the original image.



Step 6. Implement a strategy to remove the gap

Step 7. Forming of the patch from step N

Step M. Synthesis the whole texture image

Fig.4. Algorithm for texture image synthesis

Finding an optimal neighbor.

Algorithm to search for optimal "patch" is based on the following steps:

- Forming of piece with all-black color (Fig.5)
- Forming of mask image J_i

Fig.5. Algorithm to search optimal "patch"

- Calculate (Eq.1) the error Ei (x0) between Ii and T (boot image) for each displacement x0 = (Δ x, Δ y) of the input texture T (Fig.6)

$$E_i(\mathbf{x}_0) = \frac{1}{\kappa_i} \sum_{\mathbf{x}} \sum_{c} J_i(\mathbf{x}) w_c (I_{i,c}(\mathbf{x}) - T_{i,c}(\mathbf{x}+\mathbf{x}_0))^2 \quad (1)$$

T E_i

Fig.6. Determination of the error image

- Determination of error overlap of Si mask image Ii (Eq.2) and Pi selected piece (Fig.7).

$$S_i(\mathbf{x}) = \sum_{c} J_i(\mathbf{x}) w_c (I_{i,c}(\mathbf{x}) - P_{i,c}(\mathbf{x}))^2 \quad (2)$$

Fig.7. Determination of error overlap Si

- When found the patch with a Si = min to copy selected patch in the i-th image area.

The algorithm is repeated until all texture image is created.

Developed application is shown in Fig. 8.

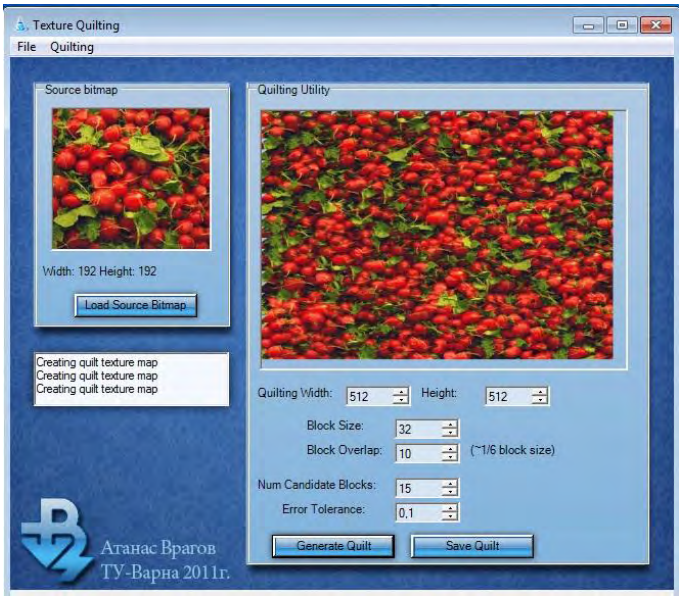


Fig.8. Texture synthesis application

I. IV. Conclusion

The results obtained are with satisfactory appearance and speed of preparation and can be used for computer graphics and visualization.

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