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Texture Synthesis Algorithm for Graphics Designers.

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The objective of this research is to develop a texture synthesis algorithm to help graphic designers generate 3D graphics that are important for improving the realism of objects and scenes. Generally, a small texture image is used to cover a large-area ground object – such as pastureland, hills, mountains, or a street paved with pebbles – by simple tiling. However, texture tiling leaves unacceptable traces in the form of visible repetition and seams.

Recently, texture synthesis has been well studied and, it is hoped, the solution to this problem is close at hand. The patch-based texture synthesis algorithm is one of the latest methods to emerge from these studies. It produces reasonable results for a wide variety of texture classes and synthesizes texture at high speed. However, it often picks patches repeatedly and the synthesized result looks directional. In this paper, a rotating patch-based sampling algorithm is presented. This texture synthesis method can decrease the error of picking repeated patches and produce a non-directional result by selecting rotating patches. It is suitable for more realistic texture synthesis, which can be used in various design areas such as fabric pattern design, and tile pattern design, etc.

Texture Synthesis Algorithm for Graphics Designers

Abstract

The objective of the research is to develop a texture synthesis algorithm to help graphic design to generate is an important 3D graphics for improving the realism of objects or scenes. Generally, a small texture or image is used to cover a large-area ground object, such as a pasture land, hill, mountain or a street paved with pebbles, by simple tiling. However, texture tiling will introduce unacceptable effects in the forms of visible repetition and seams.

Recently, texture synthesis has been well-studied and, hopefully, is able to solve this problem. Patch-based texture synthesis (PBS) algorithm is one of the latest methods among these studies. It produces reasonable results for a wide variety of texture classes and synthesizes texture with high-speed. However, it often picks patches repeatedly and the synthesized result looks directional. In this paper, a rotating patch-based sampling (RPBS) algorithm is presented. This texture synthesis method can decrease the error of picking repeated patches and produce a non-directional result by selecting rotating patches. It is suitable for more realistic texture synthesis, which can be used in various design areas such as fabric pattern design, tile pattern design, etc.

Introduction

The field of texture analysis and synthesis has been explored for a long time. DeBonet[7], who pioneered this group of techniques, samples from a collection of multi-scale filter responses to generate textures. Efros and Leung[1] provides a simple method of generating texture by copying pixels directly from the input texture with the constrain of similar neighborhood. This method is extended to multiple frequency bands and used vector quantization by Wei and Levoy[2,3,4]. These techniques synthesis texture pixel by pixel (patch size is 1 in the patch-based view), which derives methods of patch-based. Patch-based approaches tend to copy a block of pixels to the synthesis texture instead of just one pixel at a time. Firstly Guo et al.[5-8] present an algorithm for sampling blocks of pixels from input texture randomly and placing them randomly with alpha blending on the overlapped borders. This method is really fast and works pretty well on stochastic textures. Efros and Freeman[9] propose similar algorithms that improve the method of Guo et al. by the means of optimizing the choice of the patch by matching on the edge. The new methods also work well on highly structured textures but are not so fast as the first one.

The development of the Web3D technology makes digital reservation possible. It also makes it possible for entertainment and leisure websites to provide more services, such as digital virtual museums, virtual historical sites and other virtual tour-guide systems. It is hoped that even the fine mono-machine games will be offered on browsers in the near future. However, the viability of VR/3D technology mainly depends on patches. Currently, there still exists a

major problem in the patching technique. By pasting the relatively small texture samples into a patch with a big-scene area it must usually use the technique of tiling and the replicated splicing texture image to paste the patch back onto the curved surface of the big scenes, but it is unable to present this with authenticity. Due to the limitations of the bandwidth of the internet, when pasting relatively large images we have to compress them to small files to make sure that the network transmission works well. However, even if the limitations of the bandwidth are no longer a problem, texture mapping is usually created from the images scanned into the computer from the digital camera to achieve a lifelike effect. As to texture mapping for a large image, we can only sample the partial characteristics and make the whole texture by hand; therefore, the texture design work is extremely difficult.

Our research is aimed at introducing a new method called rotating patch-based sampling texture synthesis into the Web3D pasting technique, so as to avoid the repetition of tiling and to make the content of Web3D look more natural and vivid. The large scenes of Web3D are usually natural scenes with mainly a random texture. Therefore, rotating patch-based sampling texture synthesis is aimed at random texture synthesis and characterized by fast speed and good effect when dealing with all kinds of textures. Besides this, it converts the original non-random texture samples into random texture samples after synthesis. In this research, we will first use VRML97 to construct a Web3D webpage; then, we will use this synthesis method to create a large area texture patch from a small texture sample. In addition, we will compare the speed and characteristics of the patch with those of the tiling patch. Therefore, we can indicate what the future research will be.

Patch samples with 64*64 pixels will be used in this research to insure that the network transmission works well, and to show that the texture synthesis can create unlimited synthesized patches as texture synthesis technology is applied for a large ground-scene area. The textures are mainly common natural textures, and the types of textures are categorized into natural textures and artificial textures. Natural textures include grassland, rocks, asphalt roads, and snow fields. Artificial textures include artificial ceramic tiles and carpets.

Research Methodology and Proposal Structure

In this chapter, we will discuss the research methodology and proposal structure as well as what has been achieved up to the present. (1) Introduce a new random texture synthesis method called Rotating Patch-based Sampling Texture Synthesis (RPBS). This is modified from the Patch-based Sampling Texture Synthesis (PBS) initiated by Guo [5-8]. (2) Then, demonstrate that RPBS results in a random texture, and compare the result of RPBS with the result of PBS [5-8]. (3) Construct a Web3D scene, create a large-area ground texture through the RPBS and paste it to the Web3D ground scene; thereafter observe the differences in the effects of the RPBS patch and the replicated tiling patch. (4) Finally, apply the texture synthesis programming to the Web3D construction programming, compare the speed of the RPBS patching with that of the tiling patching, and provide references for relevant future research.

Rotating Patch-based Sampling texture synthesis

From extant academic papers, we know that the patch-based method is better than the pixel-based method in all aspects. However, the patch-based method still has an unresolved problem, which is how to deal with the margins of the overlap areas of the adjacent patches. Several researchers have discussed different ways, such as Image Quilting (IQ) and Hybrid Texture Synthesis (HTS), to solve this problem. Although these approaches require some complicated calculations and hence reduce the computing speed, they produce better results for large-area ground texture. A Rotating Patch-Based Sampling (RPBS) texture synthesis method, which uses the same principle as the Patch-based Sampling texture synthesis method initiated by Guo, will be applied in this research. The difference is that RPBS can provide three times more texture samples, thereby enabling it to increase the chances of a matching between texture and scene, and can be used in the synthesis of the ground texture. This approach will apply the texture synthesis method to the virtual situation of Web3D and an essential prerequisite is a higher quality of virtual environment. .

Texture Synthesis Outcome and Comparison

Now we write programs with Rotating Patch-based Sampling (RPBS) and the Patch-based Sampling (PBS) method and then run the programs respectively. The results are compared and two differences are found. First, some texture samples applied with the PBS method have a single-orientation property, yet the same samples applied with the RPBS method have a diverse-orientation property. As the textures in our research have the properties of randomness and diverse-orientation, the RPBS will give a better effect. And, when we deal with small texture samples, such as the artificial random-texture samples in Figure 1, we synthesize the samples with RPBS and PBS (PBS is applied through programming). These samples are random yet single-oriented. After comparing the results from RPBS and PBS, the RPBS result shows randomness and diverse orientation, yet the PBS result shows randomness and single orientation, the same with the samples. The result proves that RPBS can convert the single-oriented texture into a diverse-oriented one. As most of the ground textures are diverse oriented, the RPBS method initiated from this research demonstrates that it is indeed applicable in this respect.

The second difference is that many texture samples computed by the PBS method will expose the weakness of repetitive selection. The reason might be the limitations of the selectable texture samples. However, the synthesis result of RPBS reduces the repetitive selection because RPBS has three times more texture samples. These two differences show that, although the Rotating Patch-based Sampling increases the computing time by four times, it produces a diverse-oriented synthesized texture, which is closer to the true texture; meanwhile, it has a better synthesis effect than the PBS method and is more applicable to the ground texture.

Except for the differences above, the orientation property of the texture samples can be greatly changed by using the RPBS method, as shown in Figure 1. The result of PBS is similar to the original, yet the result of RPBS is obviously different.

In Figure 2, the left figure shows the repetitive selection of the synthesis outcome using the PBS method. The right figure shows that, through the RPBS method, the original sample revolves and the number of samples increases by four times; therefore, it is easier to find the matching patch and avoid repetitive selection.

Construction of a Web3D Scene

As our research will be applied to the Internet, we will construct a simple Web3D scene to test the effect of applying the RPBS method in a large-area patch, and to compare the patch effect with the commonly used repetitive tiling. In this experiment, we construct a scene that includes mountains, trees and sky. The whole document is 54.9 KB. To make it easy for browsers, we construct a free video camera from their viewpoint. Browsers can control the mouse and move freely within this Web3D scene. The movement method is designed as walking, so we can observe the changes of the texture-synthesized patch during the height-fluctuating movement. As shown in Figure 3 and Figure 4, the texture-synthesized effect of RPBS is indeed natural.

Conclusions and Discussions

(1) The Rotate Patch-Based Sampling texture synthesis method introduced in this research paper is applicable to ground texture synthesis and has the properties of diverse orientation and low repetitive selection. The synthesis outcome shows more natural random ground texture. Yet, it has the same advantage as the Patch-based Sampling method in that the operation is immediate and the effect is of high quality.

(3) This research can help solve the patching problem of large-area textures in the 3D/VR field, and increase the speed of creating different types of large-area textures. Meanwhile, this research has the promising prospect of being applied to network games, virtual society, virtual travel and other future Internet developments.

(4) RPBS can change a single-oriented texture into a diverse-oriented texture. The texture's entire characteristics are changed so much that it seems to be an almost completely new texture. Therefore, the RPBS method can be considered a breakthrough in texture design, which can be equally applied to webpage design, industrial design and even fashion design.

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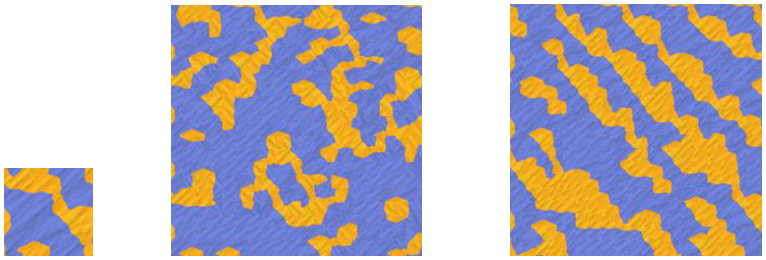
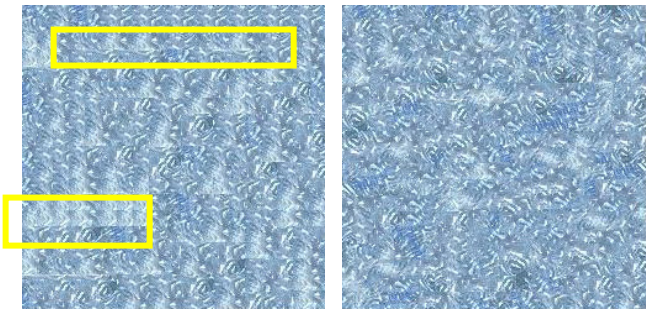
Figures



(a) (b) (c)

Figure 1: (a) is an artificial random-texture sample, (b) is the synthesis result using the RPBS method, and (c) is the synthesis result using the PBS method. Sample (a) shows the texture of randomness and single orientation, (b) shows the texture of randomness and diverse orientation, and (c) shows the texture with randomness and single orientation, the same as with (a)



(a) PBS (b) RPBS

Figure 2: (a) shows the repetitive selection of the synthesis outcome using the PBS method. (b) shows that, through the RPBS method, the original sample revolves and the number of samples increases by four times; therefore, it is easier to find the matching patch and avoid repetitive selection.

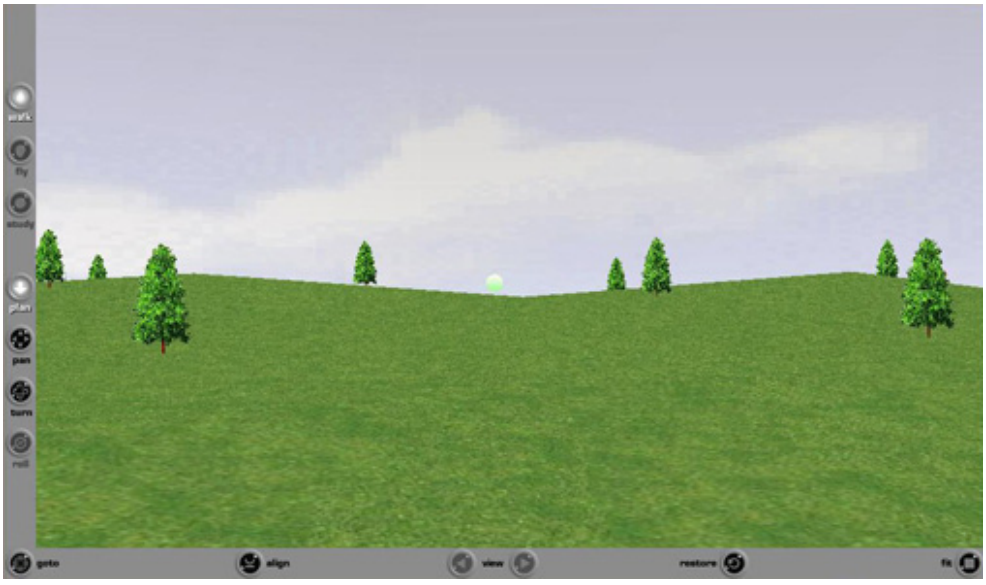


Figure 3: The Web3D scene using the RPBS method looks natural and true.

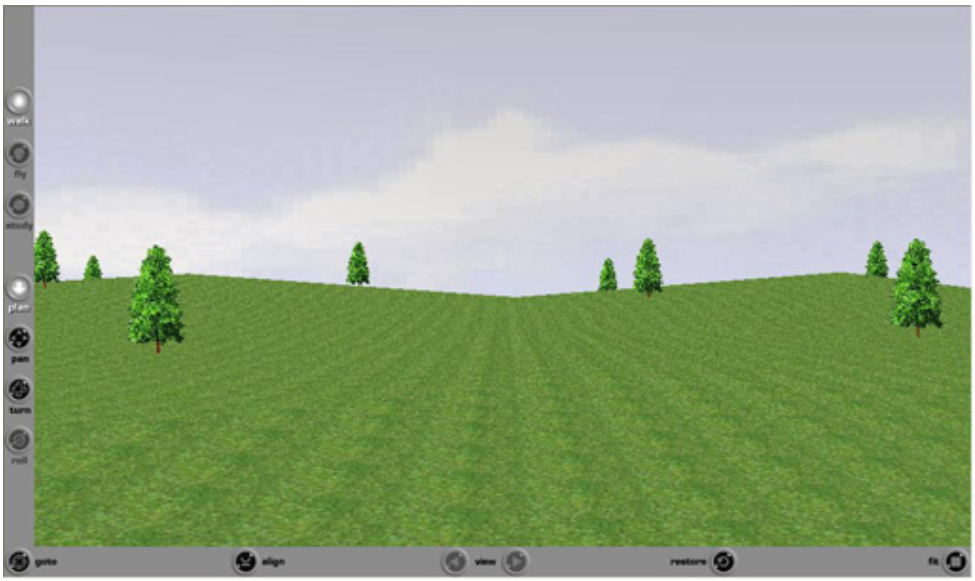


Figure 4: The Web3D scene using the commonly-used tiling patch is obviously repetitive.