Solid Texture Synthesis from 2D Exemplars

Team 04

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1 INTRODUCTION

Texture synthesis is an interesting and important problem in the field of computer graphics and is one of the most essential techniques for realistic image synthesis. Texture synthesis techniques are thus of much interest. For our term project in CSE333: Computer Graphics we will implement a method for synthesizing a 3D solid texture from a 2D exemplar, based on the paper Solid Texture Synthesis from 2D Exemplars, SIGGRAPH 2007[1].

A 2D exemplar is an exemplar image of a target texture and our goal is to high-quality samples of the target texture in 3D. The texture in 3D is what we refer to as solid texture. Solid textures provide texture information not only on surfaces but also throughout the entire volume occupied by a solid object. Solid texture synthesis or STS is the process of mapping the 2D exemplar to 3D solid texture. 3D textures are difficult to obtain, this makes STS even more interesting while being an extremely challenging task.

2 LITERATURE REVIEW

Solid texture synthesis has attracted considerable research interest in the field of computer graphics and vision since it was proposed by Perlin (Perlin 1985) and Peachey (Peachey 1985). We come a long way since then and most modern Solid texture synthesis solutions like [3] and [2] are now using deep learning techniques like GANs to generate seamless solid textures from 2D exemplars that look very natural and computationally much better on the fly once the models are trained.

The scope of this project will remain limited to using a non-deep learning approach for solid texture synthesis. Keeping this in mind, a popular and effective approach for 2D texture synthesis is to simply copy patches of the given exemplar to generate a much larger 2D texture optimized to reduce seams between the patches. This approach does not extend well to 3D texture as we need to generate a value from the exemplar for each voxel such that the solid texture looks natural even when sliced through.

The paper Solid Texture Synthesis from 2D Exemplars [1] proposes using techniques from non-parametric texture synthesis together with a global histogram matching approach. The proposed solution has a global texture energy function which we try to optimally minimize in order for the solid texture to gradually deviate from the provided exemplar such that we get a solid texture that looks seamless and natural for most exemplars.

To ensure that the optimization process makes use of the full potential of a given 2D exemplar, the optimizer must not get stuck in local minima i.e. starts using the same patch of exemplar again and again. To prevent this, authors use a popular digital image processing technique called Histogram Matching. Histogram matching ensures the use of the entire exemplar and the authors note that the final result is much better in quality and performance.

2D exemplars contain the basic three R, G, and B color channels for each texel, however, the paper experiments with the use of more channels, which are displacement, shininess, and specularity. Which the authors note is very non-trivial to accomplish and sometimes not possible for certain textures. Another important provision that the paper provides is synthesis control which allows us to fine-tune the final output for a particular texture.

3 MILESTONES

S. No.	Milestone	Member
	Mid evaluation	
1	Render complex 3D models like Stanford Bunny	Vishwesh Vhavle
2	Collect 2D exemplars and perform basic 2D to 3D mapping	Mrishika Nair
3	Implement stochastic texture synthesis algorithm with texture energy optimization. (Shared Milestone)	Vishwesh Vhavle Mrishika Nair
	Final evaluation	
4	Adding Histogram Matching to improve Solid Optimization (Shared Milestone)	Vishwesh Vhavle Mrishika Nair
5	Use the algorithm to generate texel values for each voxel from exemplar	Vishwesh Vhavle
6	Add Displacement, Shininess, and Specularity and Synthesis Control	Mrishika Nair

REFERENCES
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[2] Tiziano Portenier, Siavash Arjomand Bigdeli, and Orcun Goksel. 2020. GramGAN: Deep 3D Texture Synthesis From 2D Exemplars. In *Advances in Neural Information Processing Systems*, Vol. 33. Curran Associates, Inc., 6994–7004. https://proceedings.neurips.cc/paper/2020/hash/4df5bde009073d3ef60da64d736724d6-Abstract.html
[3] Xin Zhao, Jifeng Guo, Lin Wang, Fanqi Li, Junteng Zheng, and Bo Yang. 2022. STS-GAN: Can We Synthesize Solid Texture with High Fidelity from Arbitrary Exemplars? https://doi.org/10.48550/arXiv.2102.03973 arXiv:2102.03973 [cs, eess].