3D Reconstruction and Style Transfer

Final Project Proposal
for EN.601.661 Computer Vision

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1 Project Description

In the class, we learned how to use pictures from uncalibrated cameras to estimate the 3D structure of objects in the real world. Many powerful 3D reconstruction applications are built upon this method. Usually, the reconstructed 3D mesh is rendered according to the pixel color in the multi-view pictures. However, adapting the style transfer idea that commonly applied to 2D images, we plan to realize a style transfer algorithm to generate new textures for 3D meshes. The algorithm synthesize a specific texture with some property from a template 2D image and then apply the style to the target 3D mesh. We will fist reproduce the 3D reconstruction algorithm and then complete the style transfer algorithm. The approximate technical implementation detail is described as follows.

step 1: **3D reconstruction using Structure from Motion (SfM) [1].**
We will first self-collect a bunch of images around single object from multi-views. Then the SIFT features for each image will be detected and extracted, and for each pair of the images, we will match the extracted feature descriptors for later computing the fundamental matrices with RANSAC algorithm. After recovering the 3D locations and poses for each track, the 3D point cloud model of the object will be reconstructed with bundle adjustment.

step 2: **From 3D point cloud to polygon mesh [2].**
In this section, we will briefly introduce the method we used to convert the point cloud data into meshes. First, we need to smooth the data using the least square method. Then we will extract the plane model from the data and compute the corresponding polygon. Finally, we will run a greedy surface triangulation algorithm to obtain a triangle mesh based on projections of the local neighborhoods, which form the polygon mesh.

step 3: **3D neural style transfer [3].**
Given a 2D style image, the 3D reconstructed model will be re-rendered using a ConvNet-based method. Gram matrix extracted from VGG-Net will be used as style features. By defining the a proper formulation of content loss and style loss for gradient descent, the shape of the 3D polygon mesh will retain and the texture of it will have similar style with the input style image.

2 Team Member Assignments

Yue Fan takes charge in realizing the function of SfM and designing a user friendly interface for the whole project. Qihao Liu is responsible for a function that can convert point clouds to polygon mesh with suitable data structure for the further style transfer. Kejia Ren will do the neural style transfer part.

References

[1] Noah Snavely, Steven M. Seitz, and Richard Szeliski. Photo tourism: Exploring photo collections in 3d. *ACM Trans. Graph.*, 25(3):835–846, July 2006.

[2] Zoltan Csaba Marton, Radu Bogdan Rusu, and Michael Beetz. On Fast Surface Reconstruction Methods for Large and Noisy Datasets. In *Proceedings of the IEEE International Conference on Robotics and Automation (ICRA)*, Kobe, Japan, May 12-17 2009.

[3] Hiroharu Kato, Yoshitaka Ushiku, and Tatsuya Harada. Neural 3d mesh renderer. *CoRR*, abs/1711.07566, 2017.