Conversion of RGB-D Images to Textured Triangle Meshes with GPU

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I. Background

Previous work has demonstrated the diverse capabilities of RGBD cameras, from highly accurate 3D surface mapping [2] to reliable 3D pose estimation [1, 3]. However, many algorithms attempt to store the generated environment as a RGB 3D point cloud, which is not easily adaptable to dynamic environments, is highly memory intensive for large environments, and provides no intuition to higher perception processes about distinct objects beyond a volumetric approximation. By instead extracting meaningful geometry from the RGB-D data in the form of triangle meshes, several advantages can be realized, including:

1) Greater storage efficiency
2) Ease of manipulation and modification
3) Efficient real-time rendering
4) Geometric representation conducive to low-level object segmentation as well as higher-order object recognition and manipulation tasks
5) Straightforward tradeoff between simplicity and accuracy in mesh resolution.

II. Project Scope

For this project, a portion of the full model-generation pipeline (Figure 1) will be implemented utilizing CUDA/OpenGL-based GPU acceleration. Each segment of the pipeline has elements which may benefit from GPU acceleration. The red block represets the actual mesh generatation; this is the most complicated part of the pipeline and the main focus of the project. Blue segments are trivial functions, and green blocks represent stretch goals for the project.

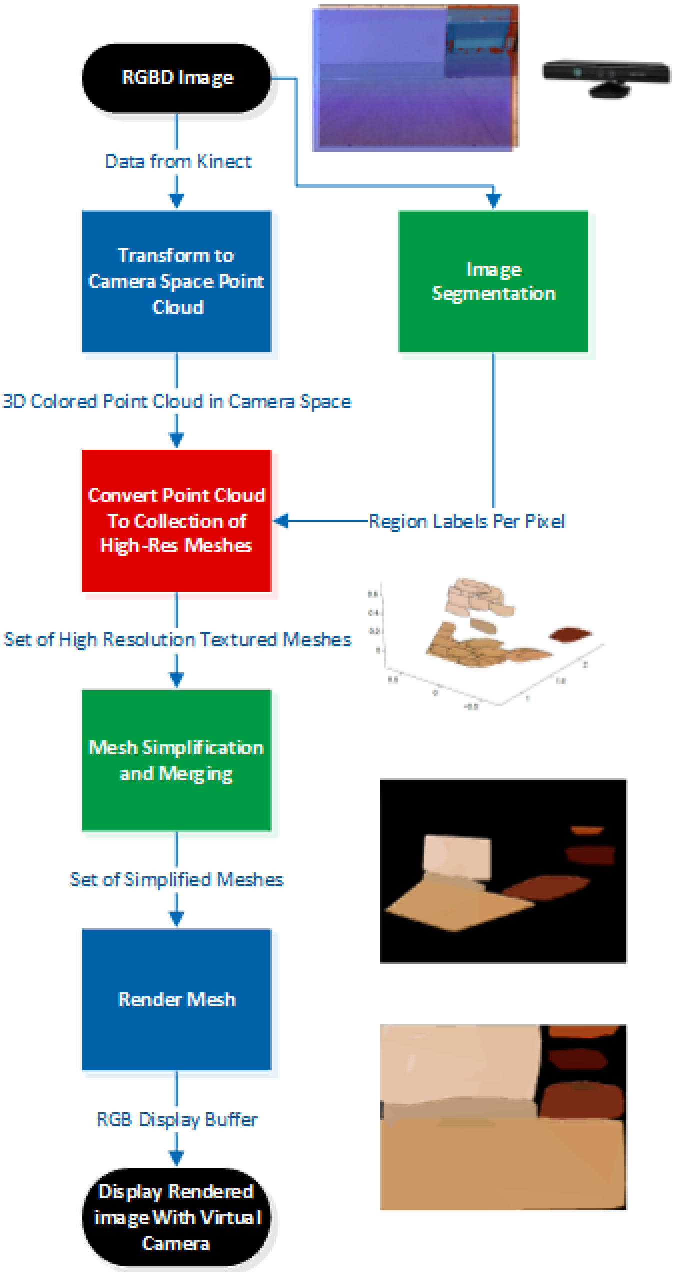
RGBD Image
Data from Kinect
Transform to Camera Space Point Cloud
Image Segmentation
3D Colored Point Cloud in Camera Space
Convert Point Cloud To Collection of High-Res Meshes
Region Labels Per Pixel
Set of High Resolution Textured Meshes
Mesh Simplification and Merging
Set of Simplified Meshes
Render Mesh
RGB Display Buffer
Display Rendered image With Virtual Camera

Fig. 1. Mesh model generation pipeline

References

[1] Felix Endres et al. "An Evaluation of the RGB-D SLAM System". In: *Robotics and Automation (ICRA), 2012 IEEE International Conference on.* (2012).

[2] Richard A. Newcombe et al. "KinectFusion: Real-time dense surface mapping and tracking." In: http://redwood.berkeley.edu/bruno/3DFM/kinect-fusion-IEEE.pdf, 2011.

[3] Yuichi Taguchi et al. *Point-Plane SLAM for Hand-Held 3D Sensors*. Tech. rep. http://www.cc.gatech.edu/~yjian6/publication/taguchi2013icra.pdf: Georgia Institute of Technology, University of Michigan.