GEO1016 Assignment 3: Reconstruction

1 Introduction

In this assignment, you will practice the whole pipeline of 3D reconstruction from images, including

- data acquisition by taking photos of real-world objects.
- reconstructing point clouds from the photos using Structure from Motion (SfM) and Multi-view Stereo (MVS).
- surface reconstruction from point clouds using open-source software for two types of objects: smooth surfaces and piecewise planar surfaces.

2 Tasks

2.1 Data acquisition

- You can use your own hand-held camera (or even a smartphone) to take photos of a real-world object of your choice (buildings are recommended).
- It is recommended to target objects with rich textures (e.g., buildings made of bricks).
- You may try to create varying overlap ratios of the images when taking the photos.

2.2 Reconstruct point clouds from the images

Software. You have the following options:

- Windows and Ubuntu users can use COLMAP[1], a general-purpose Structure-from-Motion (SfM) and Multi-View Stereo (MVS) pipeline. It has a graphical and command-line interface and offers a wide range of features for reconstruction from either ordered and unordered image collections. Please read its documentation before using it.
- macOS (and also Windows and Linux) users can use MVStudio[2], which supports all the three major operating systems. Its prebuilt executables are provided under Releases.

Data. Your experiments must be carried out on at least the following two datasets in the folder `A3_Reconstruction_Data/reconstruction_from_images`:

[1] `https://colmap.github.io/`

[2] `https://github.com/LiangliangNan/MVStudio`

- **Dataset 1**: Images of any real-world buildings. The intention of using real captured images is to better understand the requirement for data acquisition. To this end, you need to take photos by yourself. Photos of an entire large building (like BK faculty) or even the entire Delft city works in theory, but the reconstruction can be extremely slow. So please consider choosing small buildings (e.g., detached houses) or a corner of a large building.
- **Dataset 2**: The images of a wooden house provided in this assignment.

2.3 Reconstruct surface models from point clouds

- For the four point clouds in the directory `A3_Reconstruction_Data/surface_reconstruction/poisson_surface_reconstruction`, run the Poisson surface reconstruction method to obtain surface models. You can choose one of the following implementations:

  1) **Author's code**[3]. You will have to build it from its source code. Please follow the manual for building and running the algorithm.
  2) **MeshLab**[4]. Prebuilt executables for Windows, Linux, and macOS users are provided. Please refer to its documentation for its usage.
  3) **Mapple**[5]. Prebuilt executables for Windows, Linux, and macOS users are provided under Releases. The reconstruction is accessible through menu "Point Cloud" → "Poisson surface reconstruction".

- For the four point clouds in the directory `A3_Reconstruction_Data/surface_reconstruction/polygnal_surface_reconstruction`, run the polygonal surface reconstruction method (i.e., PolyFit[6]) introduced in our lecture to obtain surface models. Prebuilt executables of PolyFit for Windows, Linux, and macOS are provided under Releases. If you want to build PolyFit from its source code, please refer to its ReadMe file here.

  Note: the provided data already contains plane extraction results, and you can directly feed the data to PolyFit for reconstruction.

3 Submission

Your submission should include:

1) **Acquired data and reconstruction results (80%)**:
   - Photos you have taken. (20%)
   - Point clouds reconstructed from the photos (in `*.ply` format). (30%)
   - Surface models reconstructed from both methods (in `*.ply` or `*.obj` format). (30%)
2) **Report (20%)** (Max 3 pages excluding figures and tables).

[3] `http://www.cs.jhu.edu/~misha/Code/PoissonRecon/Version9.01/`
[4] `https://www.meshlab.net/`
[5] `https://github.com/LiangliangNan/Easy3D`
[6] `https://github.com/LiangliangNan/PolyFit`

You're expected to deliver a clear, precise, and well-structured scientific report. Make every sentence, equation, and notation precise and clear to avoid misinterpretation. Meanwhile, the report should be as concise as possible, but it should provide key information to reimplement the method to reproduce your results, and it should include:

- Description of how you took the photos to ensure good coverage of the object in the reconstructed point cloud. (5%)
- Demonstration of the reconstructed point clouds from both SfM and MVS, and the surface models reconstructed from the two surface reconstruction methods. (5%)
- Comparison of the reconstructed surface models of the two methods and discussion on how to choose between the two methods. (10%)
- Workload distribution (i.e., who did what) using a few bullet points for each member.

To promote formal scientific writing, the following rules apply for assessment:

- Any misunderstanding or misconception of main concepts: 10% deduction.
- Multiple unclear or ambiguous descriptions: 10% deduction.
- Multiple typos, grammar issues, format issues (e.g., a figure/table without a caption or multiple figures/tables with the same caption, unindexed or unreferenced figures/tables), consistency issues (e.g., upper case and lower case used interchangeably, regular font and italic font used interchangeably), misuse of symbols in notations: 10% deduction.
- If the report exceeds the length limit by more than half a page: 10% deduction.

How to submit? Compress all required files into an archive named in the following format:

`GEO1016_Assignment_3_Group_XX.zip`

where `XX` is the two-digit ID of your group (e.g., 03). If you submit an updated version, append a version number, e.g., "_v2", to the file name.