3DP Lab 2 - Structure From Motion

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May 2022

1 Introduction

The goal of this laboratory is to estimate the 3D structure of a small scene taken using our smartphone from a sequence of images with some field of view overlaps.

2 Assignment

The request of the assignment was to complete the implementation of a Structure From Motion pipeline. In particular, the goal was to complete chunks of code in 2 different `.cpp` modules:

- `matcher_app.cpp`: this module implements a feature extractor and a matcher. In this module, we had to complete **2** chunks of code in order to:
  1. Extract salient points, descriptors, and features colors from images;
  2. Match descriptors between image performing Essential + Homography geometric verification.
- `basic_sfm.cpp`: this module implements the incremental Structure From Motion pipeline. In this module we had to complete **3** chunks of code in order to:
  1. Extract both Essential matrix E and Homograph matrix H and check the number of inliers for both models to extract the seed pair. Then, recover from the selected pair the initial rigid body transformation;
  2. Add a residual block inside a Ceres Solver problem;
  3. Implement an auto-differentiable cost function for the Ceres Solver problem.

Since the code has been commented thoroughly and we do not want to write a very long report, we are going to provide directly the results we obtained. For details, we remind the reader to the code.

3 Results

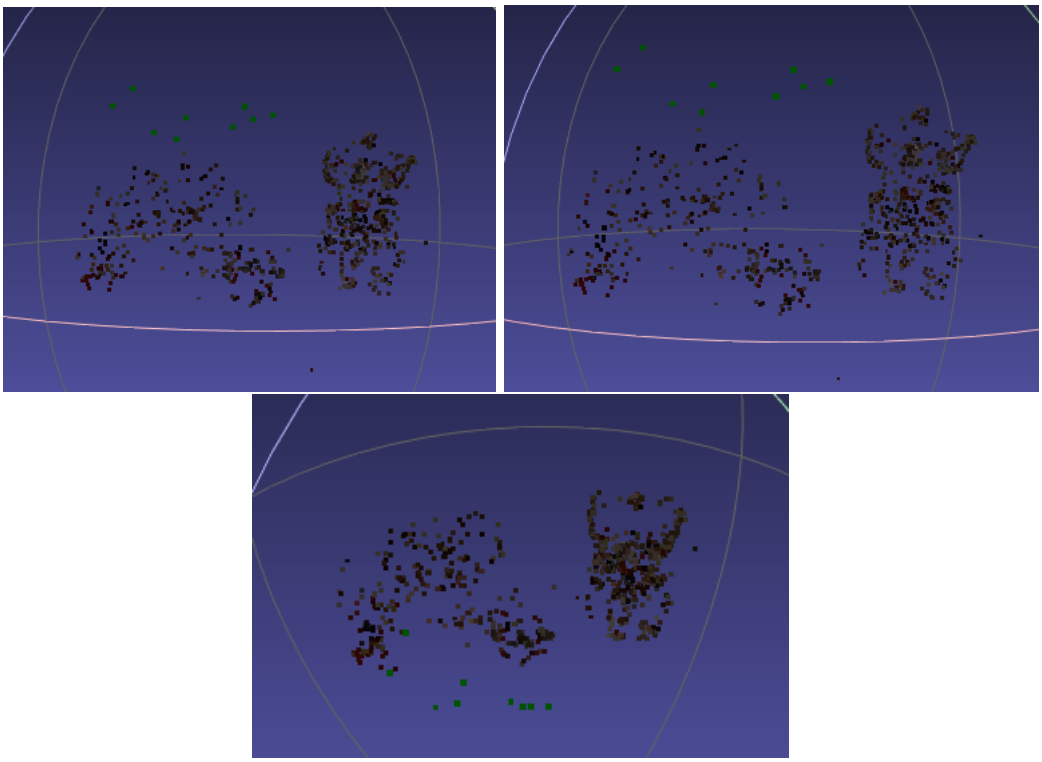
In this section, we are going to provide the results we obtained using our code by applying SfM to the dataset `images_1` and to two other datasets that we created ourselves (that we provide in the submission). In particular, we are going to show an example image for each dataset and the point cloud we obtained from it.

3.1 Dataset 1

This is the first dataset provided by the professor.

- **Example image**

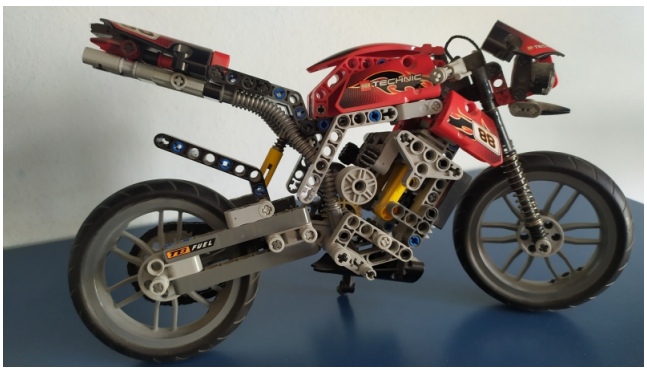
- **Point Cloud**



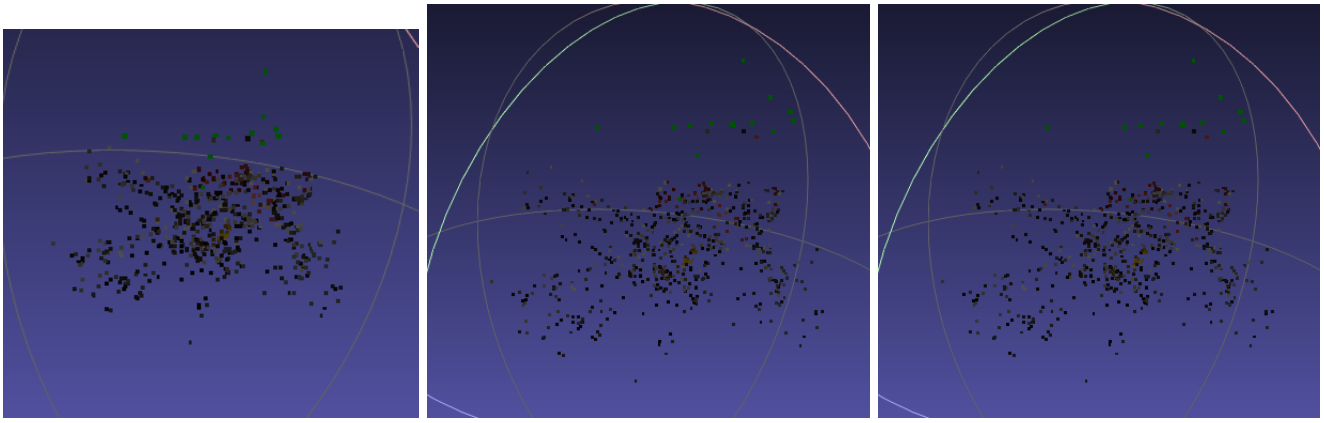
3.2 Dataset 2

This is one of the 2 datasets obtained from photos taken by our camera.

- **Example image**



- **Point Cloud**

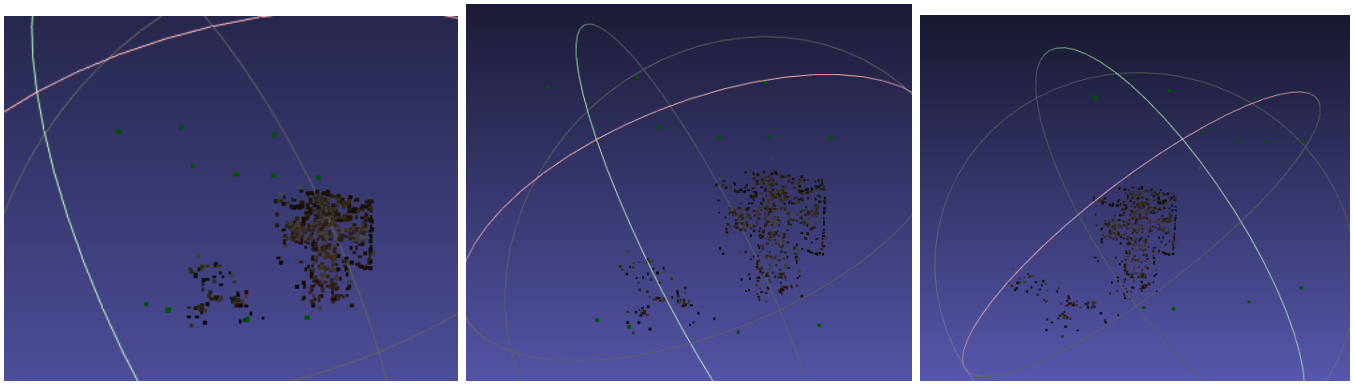


3.3 Dataset 3

This is the second dataset obtained from photos taken by our camera.

- **Example image**

- **Point Cloud**



4 Final Notes

A problem that we encountered during the development of this homework was that when running the SfM module (contained in the `basic_sfm` executable) we often obtained very bad/meaningless point cloud representations for the same `.txt` file, so for this reason we had to run many times the module before we were able to obtain reasonably good results.

This issue also occurred when we used the test data provided by the professor (i.e. `out_data1.txt` and `out_data2.txt`).

During our test we tried different feature detector algorithms (i.e. ORB and SIFT) and also different descriptor matchers such as the Brute-Force (BF) matcher and the FLANN matcher. To filter our matches we used the Lowe's ratio test, trying

different thresholds to understand if we could obtain better results.

In the end, the configuration of algorithms and parameters which gave us the best results included SIFT as feature detector algorithm, a FLANN-based matcher (with k-nn matching) and a value of 0.8 for the ratio threshold of the Lowe's ratio test.