3D-Data-Processing 2 Assignment

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1 Problem Description

The goal of this assignment was to extend the provided C++ software to implement the Structure from Motion problem. So to estimate the 3D structure of a small scene taken by smartphone from a sequence of images with some field-of-view overlaps. Then in the last part we had to implement this task with some scene taken by our smartphone and see the results.

2 Camera Calibration

The first phase to complete this assignment was to acquire a dataset using a smartphone. You can find this dataset in the *datasets/images_3* folder. It was also necessary to estimate the camera parameters (camera matrix + distortion coefficients) of our smartphone and to do this we follow the tutorial in the pdf given by Prof. Pretto (*Camera Calibration Tutorial*). We were able to obtain a reprojection error of ***0.618168***, which is quite good. We also rescale both the calibration and the dataset images using the command: ***mogrify -resize 1133x850 **.jpg***.

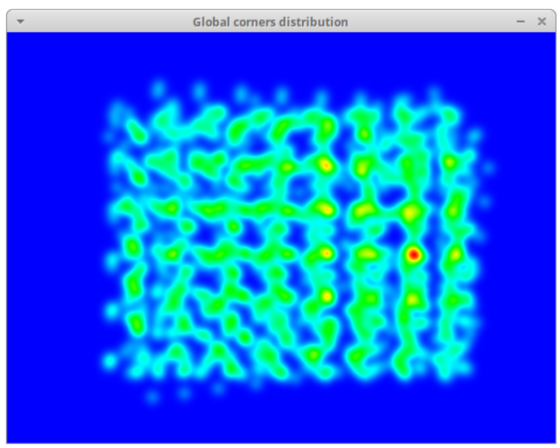

Figure 1: Calibration Output

3 Solution Structure

To reach the goal we performed some tasks following the method of Structure from Motion. We divided the problem in 6 different points as required by the problem:

- The first task referred to extracting salient points, descriptors and colors from images. After some trials with some different detector and descriptors we decided to use ***ORB*** to extract them.

- Then we had to match descriptors between images, using the Essential and Homography matrix, to perform geometric verification. So we used the ***BruteForce-Hamming*** method for matching descriptors and controlling the values from Essential and Homography matrices (we had taken only the values equal to 1) to computed the inliers.

- The third task was to search the seed pairs. For this part we checked that the number of the inliers of the model E of Essential Matrix was greater than the model H of Homography Matrix. If this condition is satisfied then we recovered the initial rigid body transformation from the new camera and the reference camera. Then we controlled that the recovered transformation is mainly given by a sideward motion which is better than a forward one. To did that we used this rule: *'If the magnitude of the x-component or y-component of translation vector is greater than the magnitude of the z-component, then the motion is predominantly sideward'.*

- Triangulate the 3D point by using the observation of this point in the camera poses. To did this we also checked the cheirality constraint for both the cameras.

- The fifth task was to implement an auto-differentiable cost function for the Ceres Solver problem, in order to solve large scale bundle adjustment. So given a set of measured image feature locations and correspondences, the goal of bundle adjustment is to find 3D point positions and camera parameters that minimize the reprojection error.

- The last task was to use this auto-differentiable cost function, to add a residual block inside the Ceres solver problem.

4 Results

In this section we show the results obtained with the algorithm on the two given datasets and on the dataset acquired with our smartphone. You can find all the results into ***Result*** folder. Files *cloud1.ply* and *cloud2.ply* are the results for the two given dataset using the data given in the assignment. The files *my_cloud1.ply* and *my_cloud2.ply* are respectively for the dataset 1 and dataset 2 using our data given by the first part of the algorithm. Finally, the file *my_cloud3.ply* is the point cloud for the dataset acquired from our smartphone.

Figure 2: Dataset 1

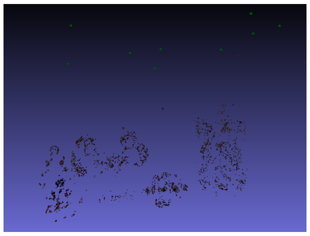

Figure 3: Output with data given in the assignment

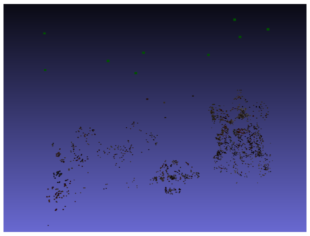

Figure 4: Output with data retrived by our matcher

Figure 5: Dataset 2

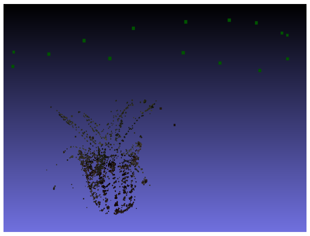

Figure 6: Output with data given in the assignment

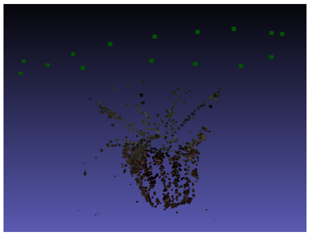

Figure 7: Output with data retrived by our matcher

Figure 8: Dataset 3

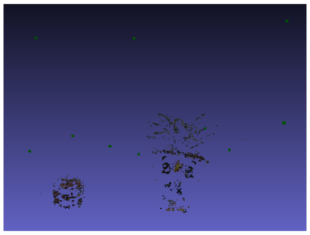

Figure 9: Output with data retrived by our matcher

5 Conclusions

In conclusions, we are satisfied with the results because the assignment was quite challenging. We had some problems with the task of searching the seed pairs, in fact, if we change some values then the results were very different. After some search we found the correct way to look if the motion was sideward or forward.

Thanks to the assignment we learned a lot about teamwork, we made video calls to discuss the different implementations of the problems and then together we have achieved the result we set ourselves. This technique of solving problems together by comparing our ideas has been very useful for us.