Answer Sheet 4

Topic: SfM, Triangulation, PnP, Bundle Adjustment

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Part 3: Bundle Adjustment

Function of Huber loss:

$$H(e) = \begin{cases} \frac{1}{2}e^2, & if|e| \leq \delta \\ \delta(|e| - \frac{1}{2}\delta), & otherwise. \end{cases}$$

When the absolute error is larger, the square function turns into linear. Therefore, we can guarantee the function won't be largely affected by the outliers, and at the meanwhile the function is still differentiable. In this way, the loss function is more robust to the outliers.
We do not need it in calibration because all of the points of the calibration board should be counted.

Part 4: Outlier Filtering

The four criteria are:

- much too large reprojection error
- too large reprojection error (only if no other types)
- too small distance to camera
- too small z coordinate

The former two outliers are mainly caused by the inaccurate reprojection and mismatch. The latter two are caused by local minima.

Part 5: Building a Map

Using match_all:
Brute-force matching 13284 image pairs...
Successfully matched 1008 out of 13284 image pairs with a total of 44367 inlier feature matches (109579 total). New total of matched image pairs is 13366.
Saved matches as matches.cereal
Built 4982 feature tracks from 58556 matches. Average track length is 5.57828.
⇒ The map has 164 cameras and 4068 landmarks with 21443 observations. 237 landmarks

were removed as outliers and 1649 observations were marked as outliers. This process takes about 10.5 minutes (Intel Core i7, GTX 1060Ti, WSL). The optimization takes the most time, especially in the last 5 minutes of the mapping. It seems quite large computation is implemented.
Suggestions: Since the processing time on optimization grows exponentially, we can expedite this process by decreasing the number of landmarks and matching points.

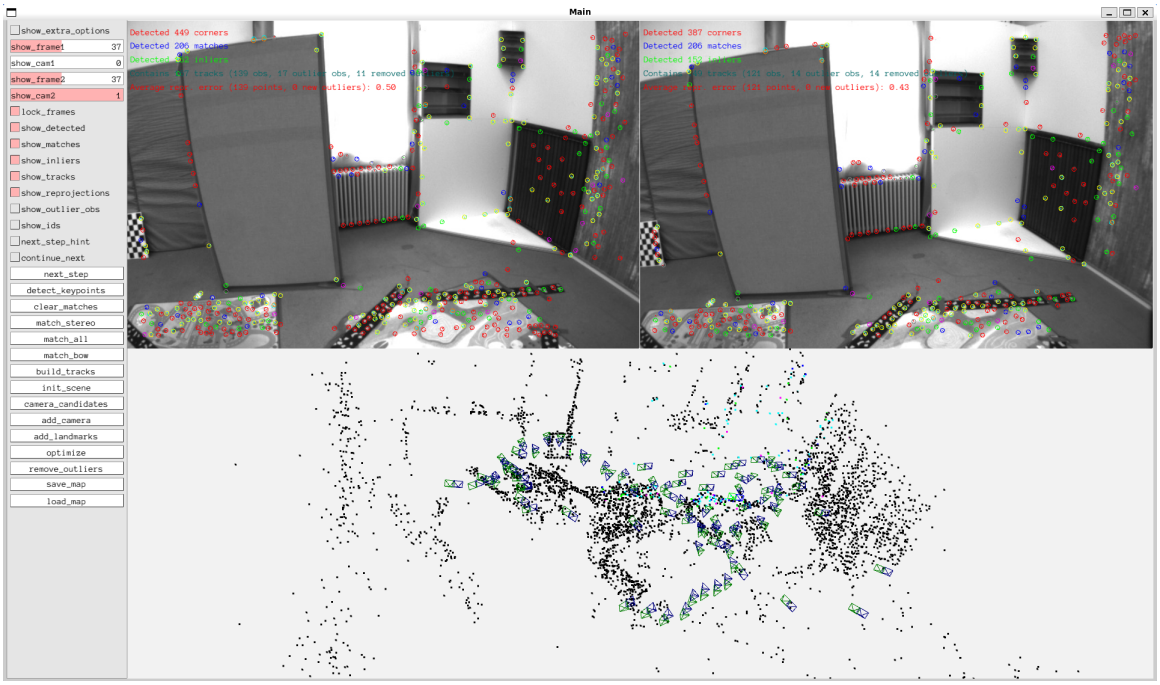

Figure 1: Map using Match_all.

Using match_bow:
Matching 3649 image pairs using BoW...
Successfully matched 454 out of 3649 image pairs with a total of 23945 inlier feature matches (43850 total). New total of matched image pairs is 3649.
Saved matches as matches.cereal
Built 3214 feature tracks from 23945 matches. Average track length is 5.43808.
⇒ The map has 145 cameras and 3045 landmarks with 15460 observations. 125 landmarks were removed as outliers and 1110 observations were marked as outliers. This process takes about 6.5 minutes, which is much faster than using match_all.

In conclusion, using BoW is more efficient than using Brute-force matching, while it sacrifices the loss of information. This also proves the former suggestion.

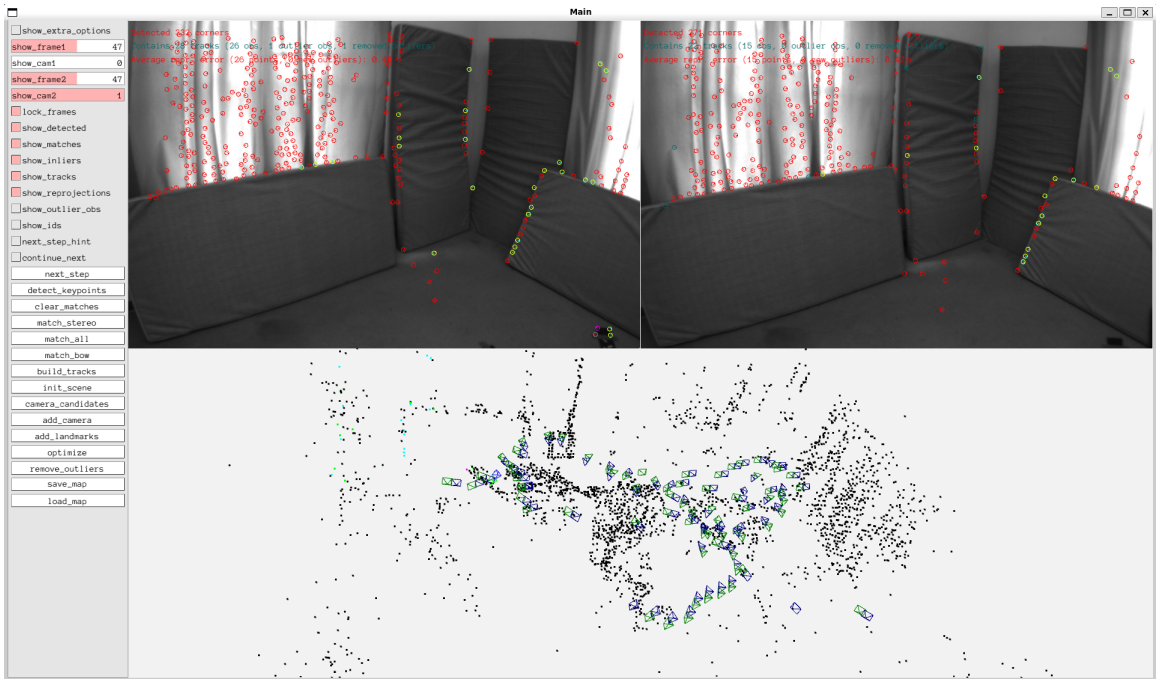

Figure 2: Map using Match_bow.