Vision Aided Navigation 2024 - Exercise 7

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August 1, 2024

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https://github.com/AmitaiOvadia/SLAMProject/blob/main/VAN_ex/code/ex7/Ex7.py
And
https://github.com/AmitaiOvadia/SLAMProject/blob/main/VAN_ex/code/utils/BundleAdjusment.py
https://github.com/AmitaiOvadia/SLAMProject/blob/main/VAN_ex/code/utils/PoseGraph.py

Question 7.1 Detect Loop Closure Candidates

For each frame iterate over all the previous frames.
find the shortest path from c_n to c_i and sum the covariances along the path to get an estimate of the relative covariance $\Sigma_{n|i}$.

- What are reasonable choices for edge weights? i.e. in what way is the chosen path the shortest?

  Each edge represented the uncertanty from trasnlating from one pose to the next, so I needed someway to

  take this uncertainty (a matrix of size 6 by 6) and reduce it to a single number.

  So I took the square root determinant of this motion covariance,

  beacuse it represented a measure proprtional to the 'volume' of this covariance

  (the volume of the elipsoid represented by the covariance at mahalanobis distance of 1).

  The path is shortest in the sense that the accumulated uncertanty, or the approximation of it along this path, is the smallest.

- How did you implement the shortest path algorithm?

  I used the networkx python library, each edge $[v_1, v_2]$ got an attribute 'weight' that represented this motion's covariance's 'volume' from v_1 to v_2.

  The fucntion signiture was:

  nx.shortest_path(self.loop_closure_graph, $source = v_1$, $target = v_2$, $weight =' weight'$).

  I think the default method they use is dijkstra.

Question 7.2 Detect Loop Closure Candidates

- What was your chosen threshold?

  For selecting the loop closure candidates I used mahalanobis distance of 750.

  And the cancidate accepted to the loop closure club if it passed the 50 inliers threshold after the ransac and pnp.

Question 7.3 Relative Pose Estimation

For every loop closure frames pair candidate I perform a small Bundle optimization to extract
the relative pose of the two frames as well as its covariance.

- What is a reasonable initial solution for the Bundle?

  The initial solution is the relative $[R|t]$ between the 2 frames obtained from the *pnp* algorithem and the RANSAC.

- How did you extract the appropriate covariance?

  I got the marginal covariance of the 2 cameras after optimizing the bundel.

Question 7.5

- How many successful loop closures were detected?

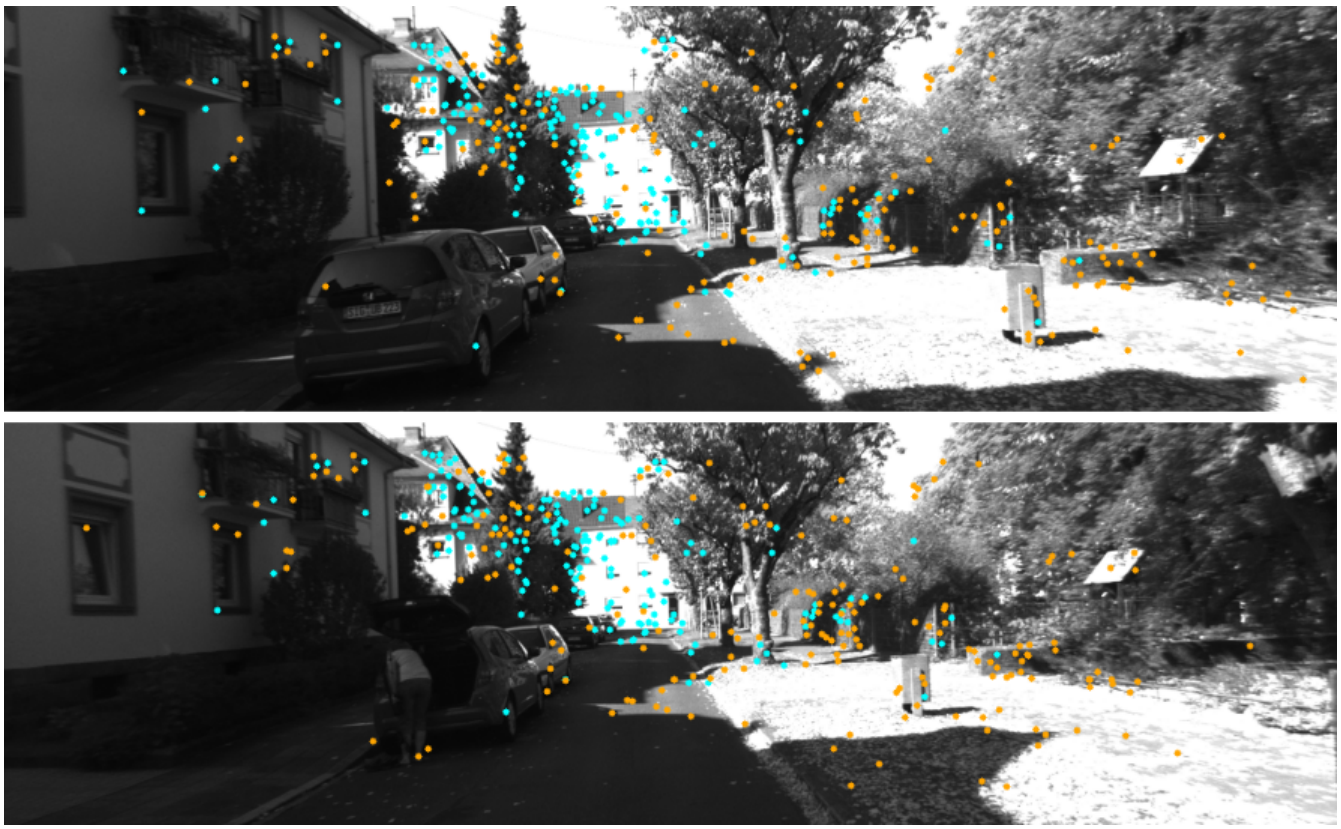
  the total number of loop closure detected was: 50 across 32 loop closure frames (frames from which at least one loop closure was detected)

  For example frame 3320 was paired with frames 315, 2366, 308, 30, 2373.

- Plot the match results of a single successful consensus match of your choice. (For the left images, inliers and outliers in different color):

  A match between frame 3217 and 2271:

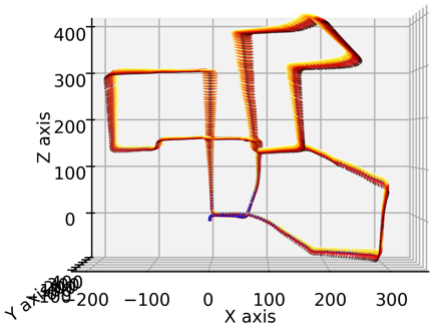
  Inliers in cyan and outliers in orange.



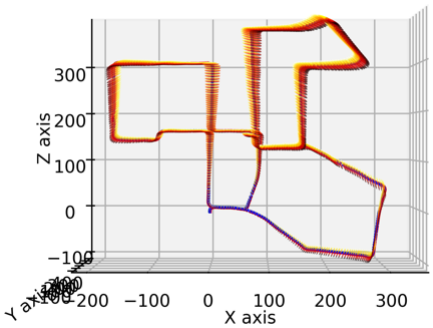
- Choose 4 versions of the pose graph along the process and plot them (including location covariance).

  Explain at what points you chose to plot the graph.

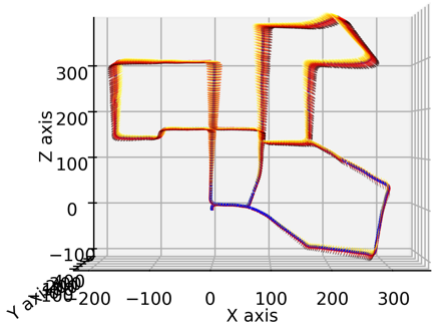
  Before optimization:



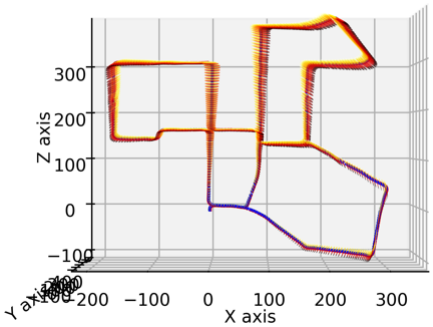
  After the first loop closure (you can see that the trajectory is more straight, but the covariances don't seem to change)



  After half of the loop closures:

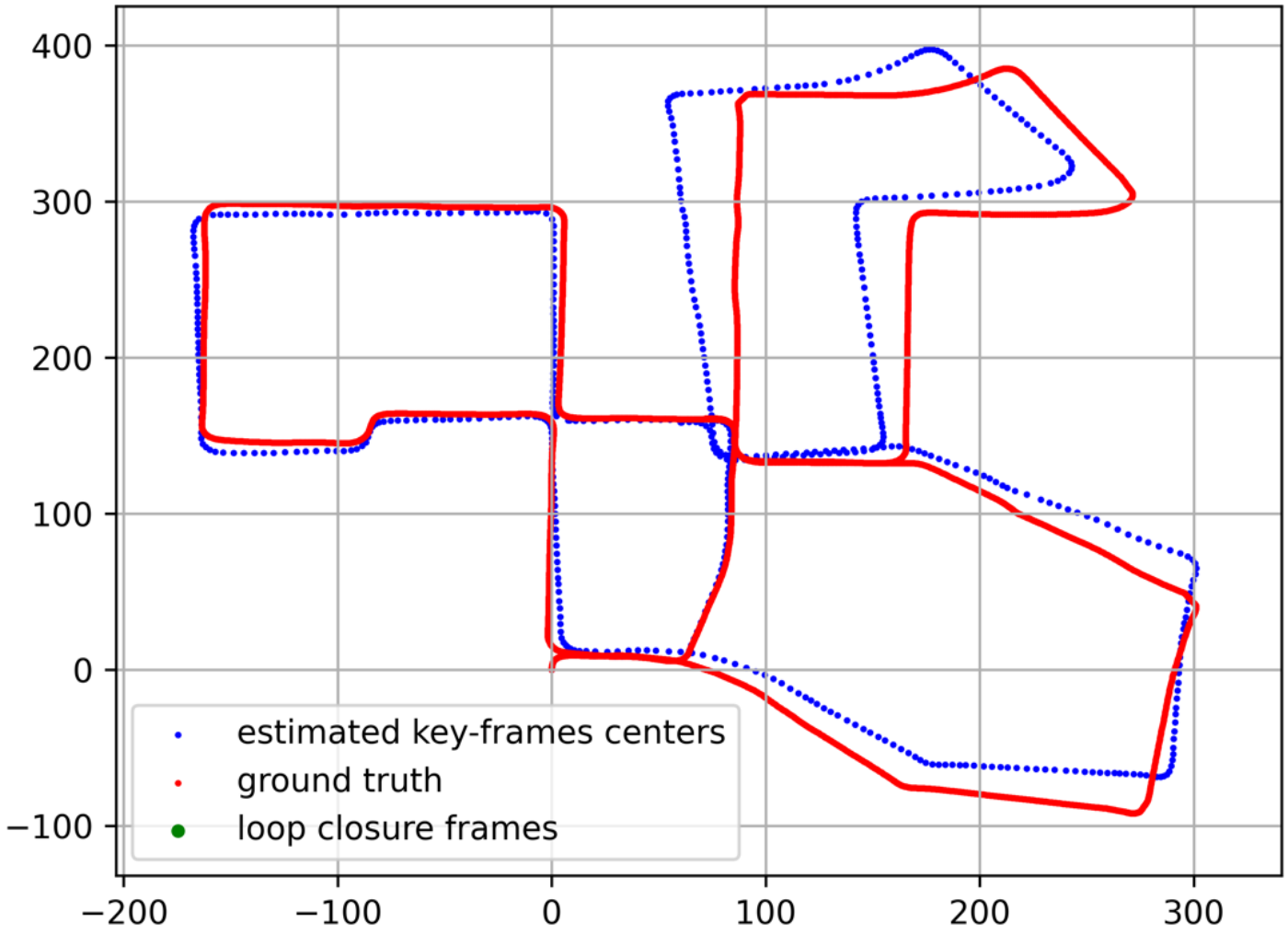


  After optimization ended

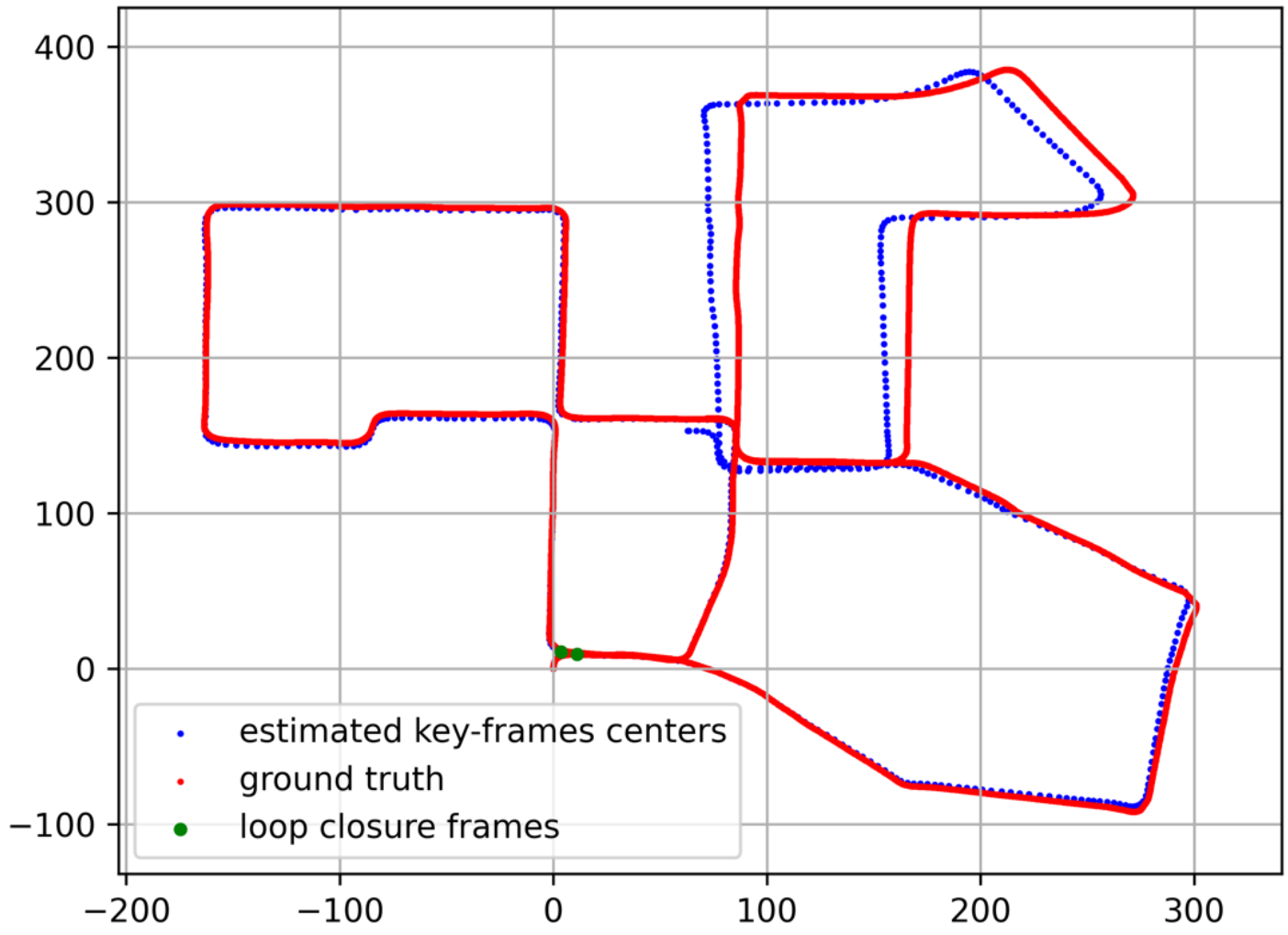


- Plot the pose graph locations along with the ground truth both with and without loop closures.

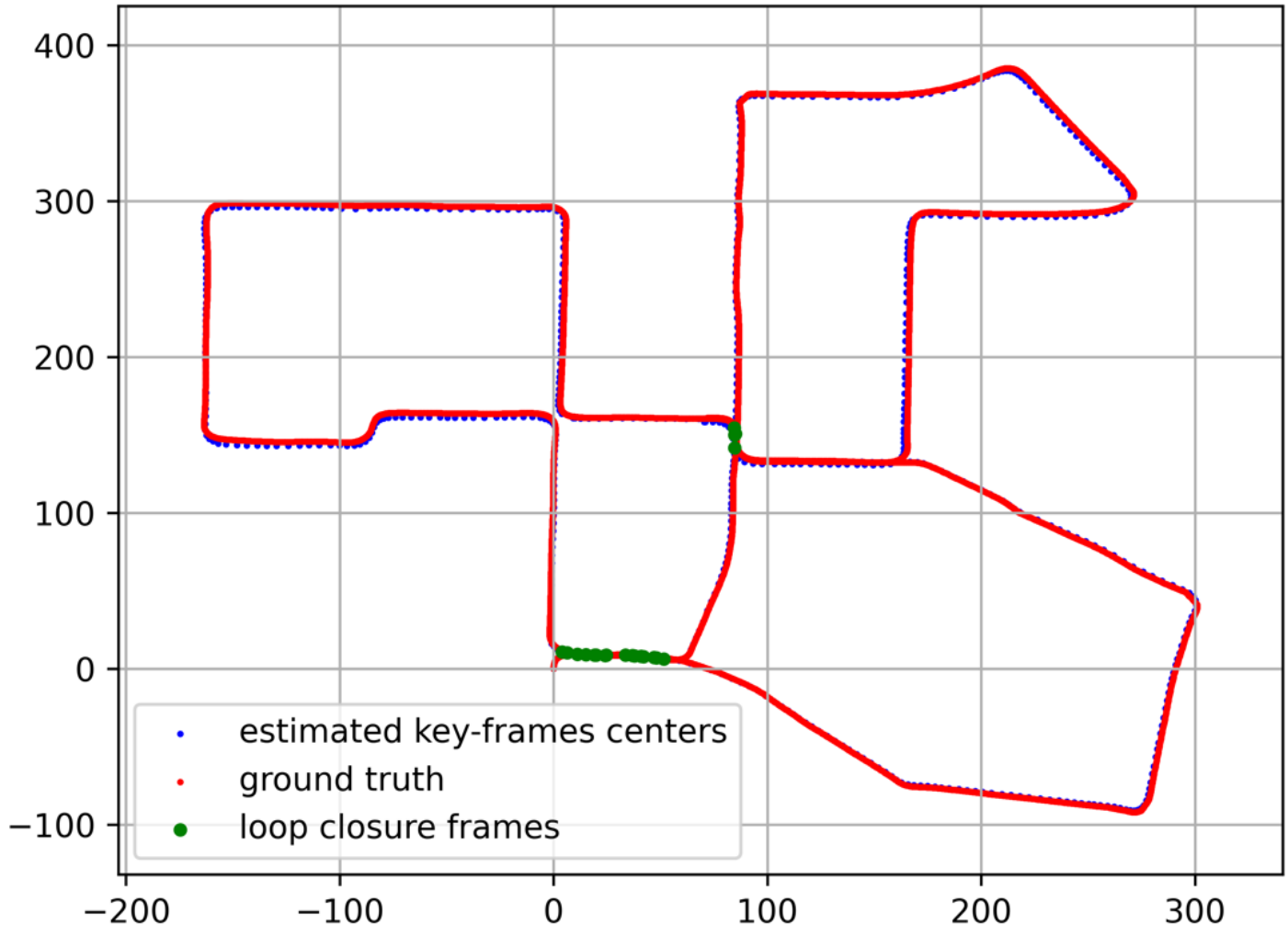
  Before optimization:



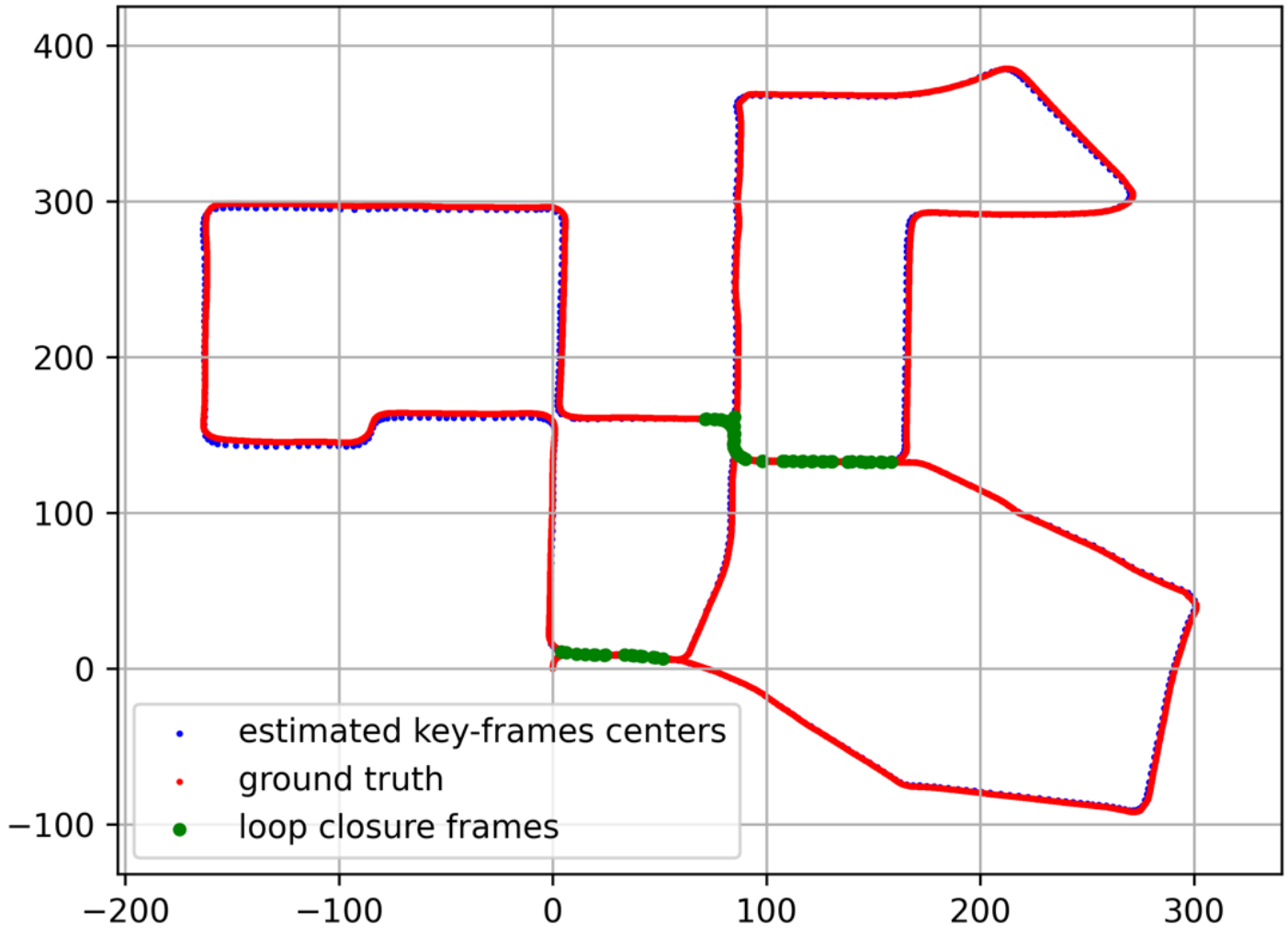
- After the first loop closure:



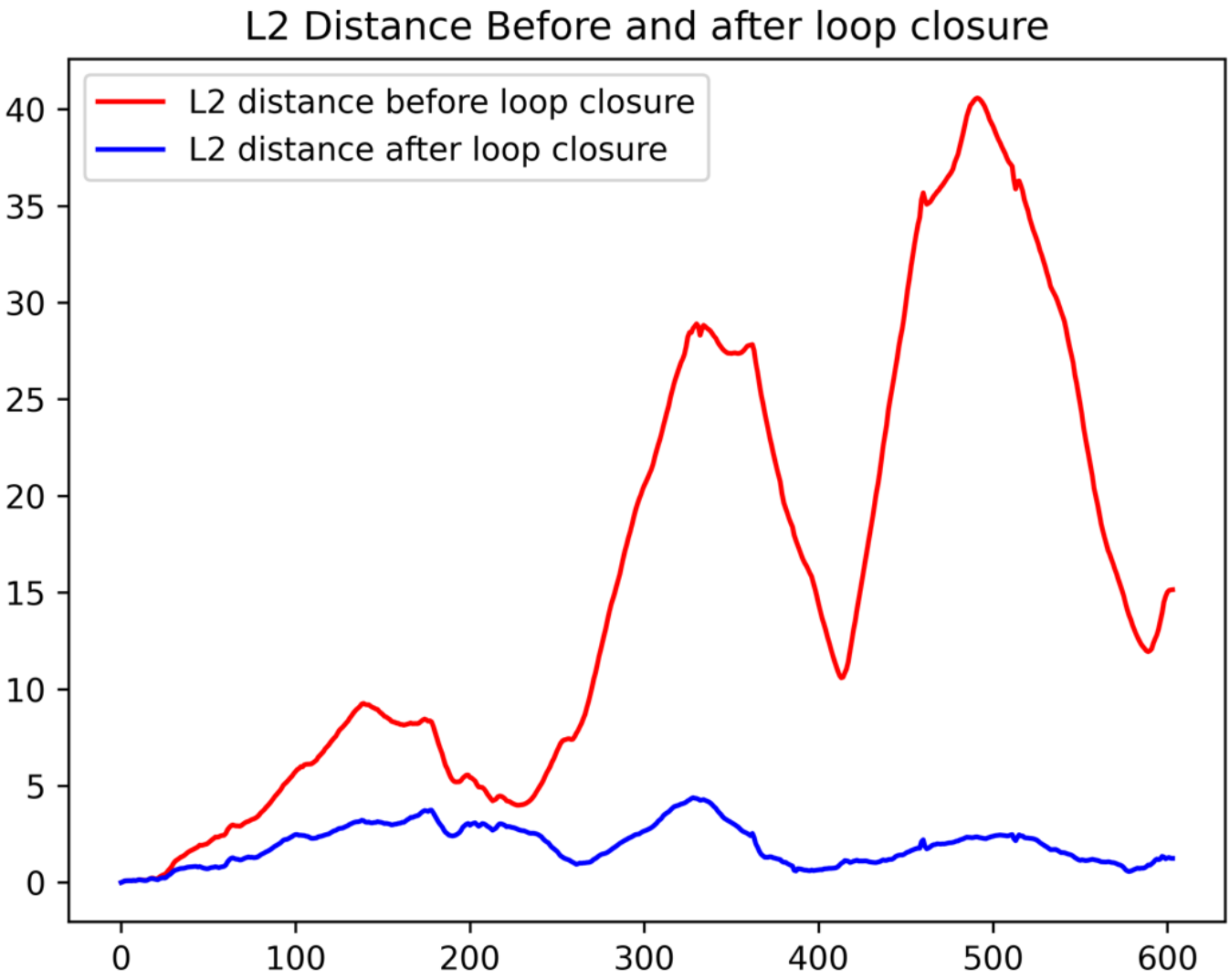
- After the second loop closure area:



- After the end of the loop closure optimization:



- Plot a graph of the absolute location error for the whole pose graph both with and without loop closures:



- Plot a graph of the location uncertainty size for the whole pose graph both with and without loop closures. (What measure of uncertainty size did you choose?)

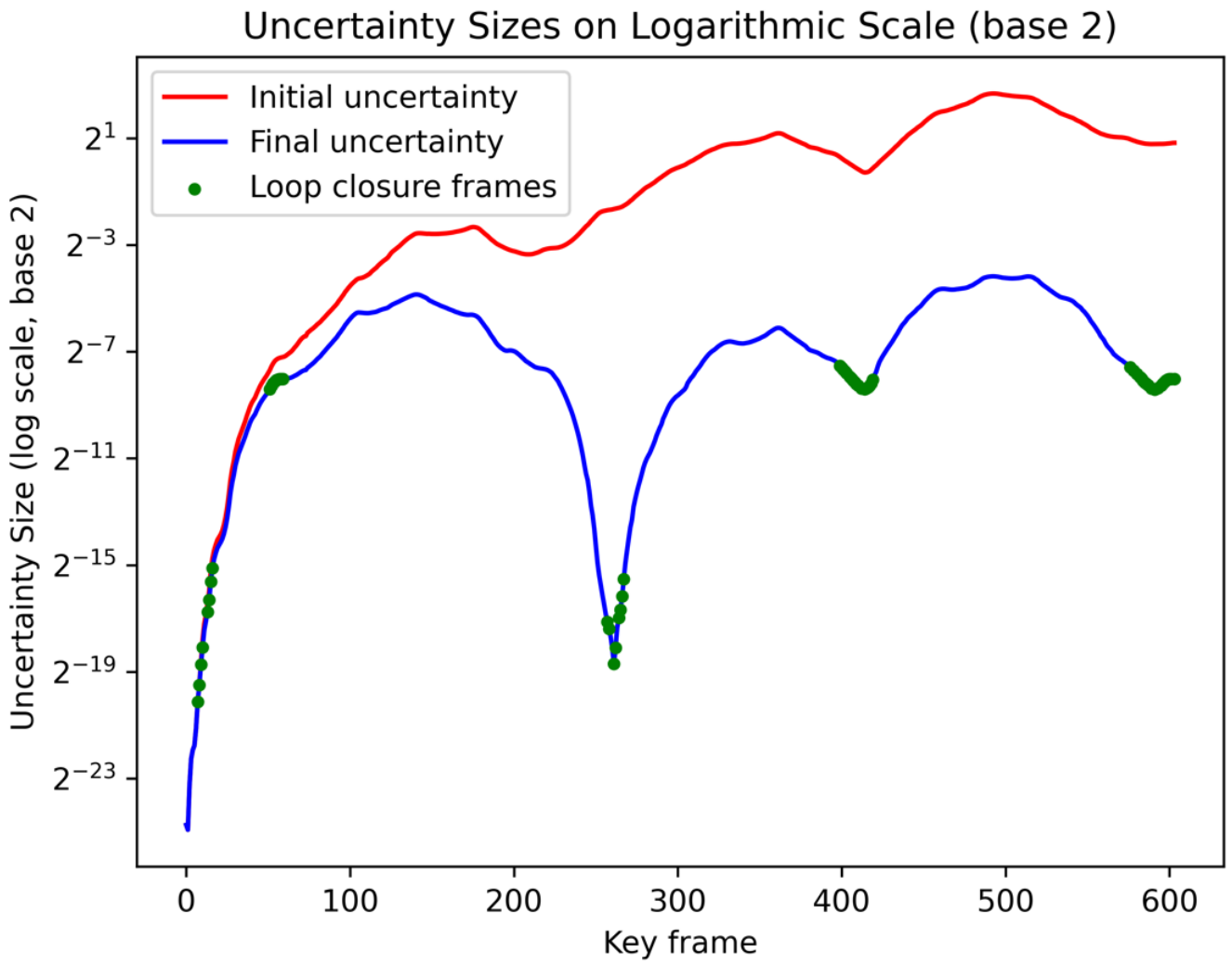
  The measure of uncertanty that I chose was as follows:

  I took $\Sigma_{k|0}$ the marginal covariance between the key-frame k and the starting frame 0.

  I took the bottom right 3×3matrix $\Sigma_{k|0}[3:,3:]$ which corresponds to the location covariance

  And I computed the square root of the determinant of it, which is proportional to the

  'volume' of the elipse that corresponds to this covariance.



It's clear that the uncertainty is reduced in the areas where there are loop closures, and it is much better than the initial uncertainty.