Vision Aided Navigation 2022
Project Report

Over the semester we implemented a system that estimates the trajectory of the vehicle from a video captured with an onboard stereo camera.

The system uses a suite of algorithms in several stages to achieve this goal. In the final project report we present the different parts of the system, explore their properties and the quality of the estimation.

Present in your own words the different stages of the system. Summarize the ideas and algorithms as you comprehend them. The discussion should include:

1. Introduction and overview: provide a brief background and explain why the problem is important.

2. Code: For each stage of the process what is the relevant code that implements this stage. State what are the main functions used in the process, what each one does and where in the code it can be found (function name, file name, line number)
The code should be readable and well documented.

3. Performance Analysis (חקר ביצועים): A detailed quantitative and qualitative analysis of the different stages of the system.
Where relevant describe what you did to improve weak points, what was the change you implemented and what impact it had.

4. Discussion and Conclusions: Summarize the report and provide some criticism: identify weak points, unrealistic assumptions or aspects that could be improved. Suggest how you would improve the system and what are good directions for future research.
If you researched or implemented anything extra above what was required, describe what you did, the motivation and results.

Performance Analysis

Present any graph, figure or statistic that demonstrates the performance of the different stages of the system as well as the system as a whole.
For each graph, provide an analysis of the information presented in the graph, highlight what the graph shows and explain what aspect (positive or negative) it demonstrates.
Where appropriate combine different data in the same graph. Crop the data such that the result is presented in a meaningful manner. **Each figure should be numbered.**

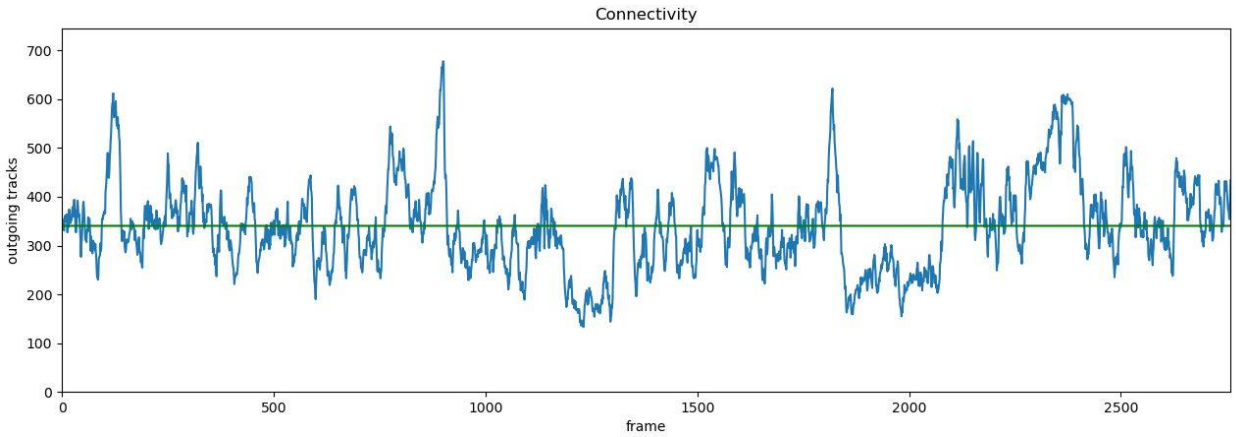
Present the following tracking statistics:

- Total number of tracks
- Number of frames
- Mean track length
- Mean number of frame links
- A graph of the number of matches per frame
- A graph of the percentage of inliers per frame

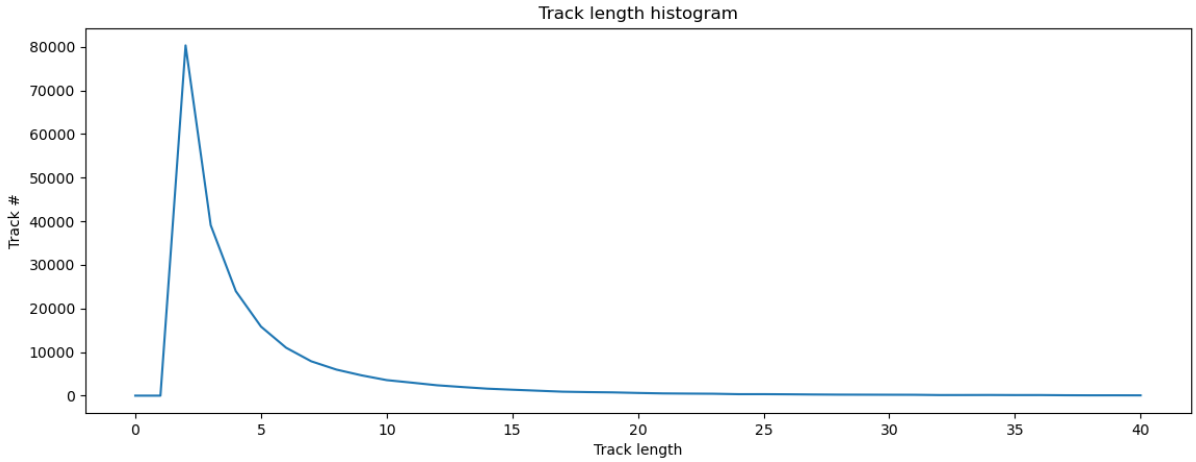
Add any graph / figure that you think presents the information and demonstrates the ideas you want to convey. A list of suggested graphs includes:

- **Note**: While including all the suggested graphs is not mandatory, it should include at least a substantial subset of them, and enough to convey the main points. Any additional graph that you think sheds light on some aspect or adds clarity is welcome.

- Connectivity: For each frame, the number of tracks **outgoing** to the next frame (the number of tracks on the frame with links also in the next frame)

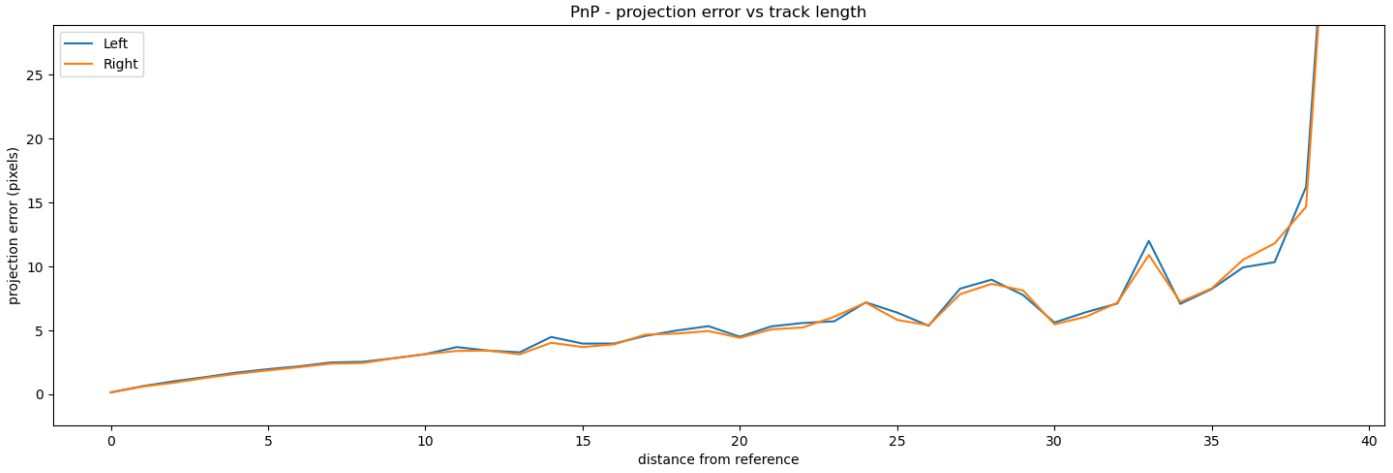


- Track length histogram



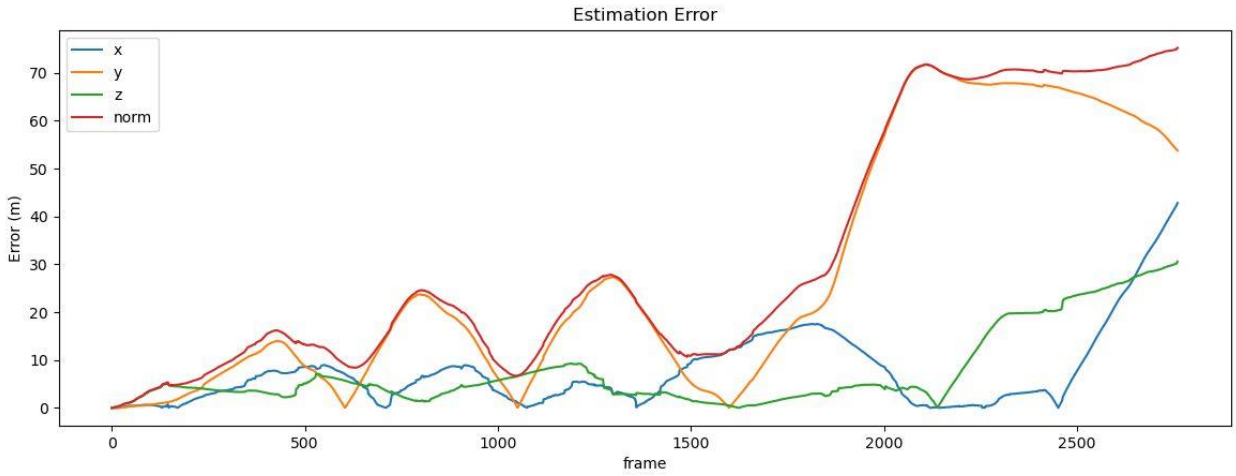
- Median (or any other meaningful statistic) projection error of the different track links as a function of distance from the reference frame (1st frame for Bundle, triangulation frame for PnP)
    - for PnP estimation
    - for Bundle estimation

  Note that for this and other similar graphs the required information can take a while to collect for all the tracks. A graph of a representative subset of the tracks can be a good approximation - Explain how you chose this subset.



- Median (or any other meaningful statistic) factor error of the different track links as a function of distance from the reference frame
    - for PnP estimation (initial solution)
    - for Bundle estimation (optimization result)

- Absolute PnP estimation error:
    - X axis error, Y axis error, Z axis error, Total error norm
    - Angle error



- Absolute Pose Graph (**without** loop closure) estimation error:
    - X axis error, Y axis error, Z axis error, Total error norm
    - Angle error

- Absolute Pose Graph (**with** loop closure) estimation error:
    - X axis error, Y axis error, Z axis error, Total error norm
    - Angle error

- Relative **PnP** estimation error:
  The error of the relative pose estimation compared to the ground truth relative pose, evaluated on sequence lengths of (100, 300, 800).
    - X axis, Y axis, Z axis, Total error norm (measure as error%: m/m)
    - Angle error (measure as deg/m)
    - For each graph calculate the average error of all the sequences for total norm and angle error (a single number for each)

- Relative **Bundle** estimation error:
  The error of the relative pose estimation compared to the ground truth relative pose, evaluated on sequence lengths of (100, 300, 800). Choose closest keyframe if necessary
    - X axis, Y axis, Z axis, Total error norm (measure as error%: m/m)
    - Angle error (measure as deg/m)
    - For each graph calculate the average error of all the sequences for total norm and angle error (a single number for each)

- Number of matches per successful loop closure frame
- Inlier percentage per successful loop closure frame

- Uncertainty size vs keyframe – pose graph **without** loop closure:
    - Location Uncertainty
    - Angle Uncertainty

- Uncertainty size vs keyframe – pose graph **with** loop closure:
    - Location Uncertainty
    - Angle Uncertainty

  How did you measure uncertainty size? How did you isolate the different parts of the uncertainty?