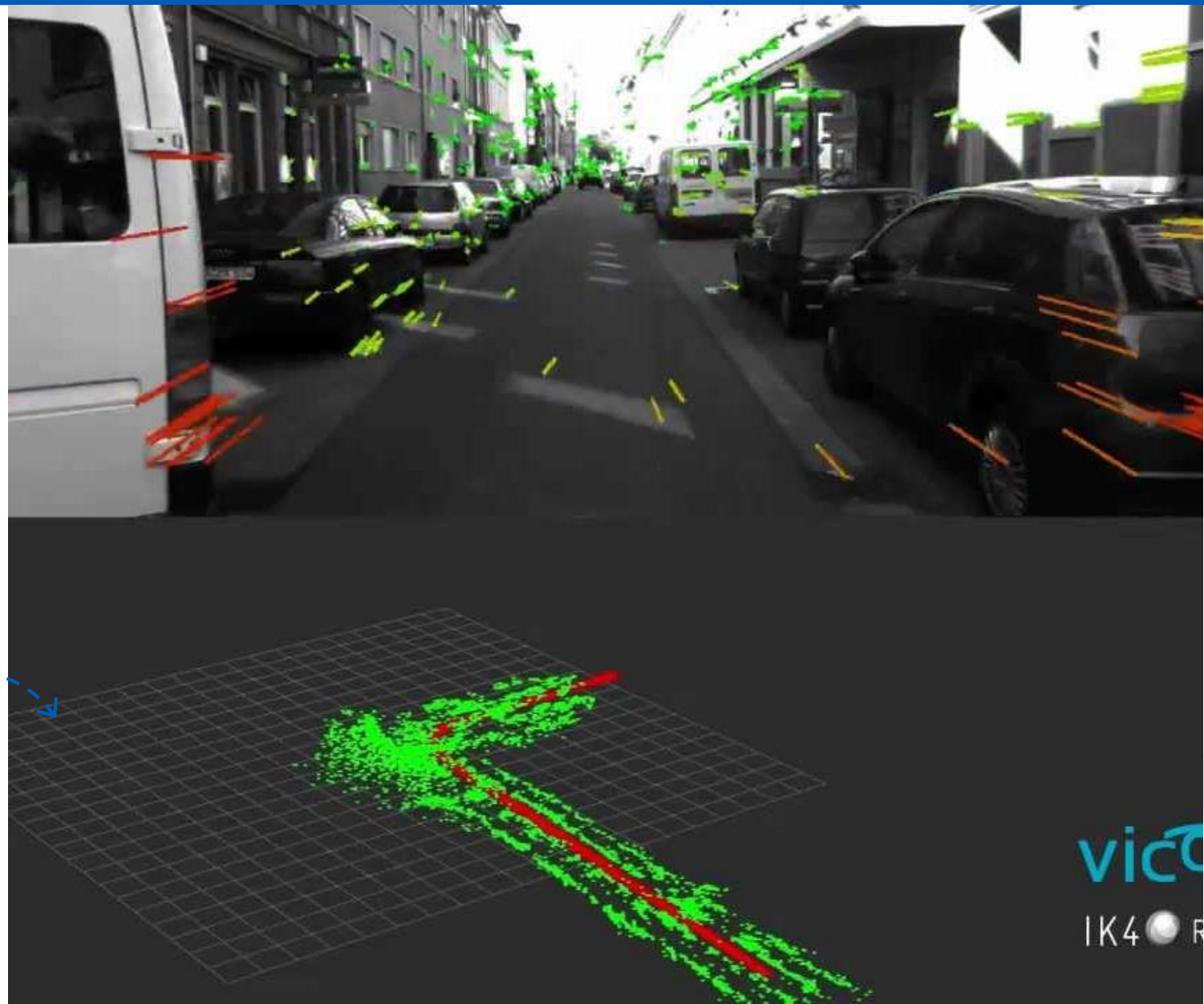
VISUAL MONOCULAR ODOMETRY

Junqi Wu

University at Buffalo The State University of New York

Introduction

Odometry is the process of estimating one's position and plays a critical role in the navigation pipeline of autonomous systems such as robots, drones, and autonomous vehicles. This project develops and improves on odometry methods using computer vision.



A self-driving car localizing itself using a camera feed.

Project Overview

Monocular visual odometry uses a sequence of images from a single lens camera to estimate the trajectory and position of said camera.

Key points are tracked in between frames using FAST corner detection and KLT optical flow tracker.

The transformation between frames is then estimated using RANSAC

Key points detected in a frame

$$E = U\Sigma V^T \qquad R_{pos} = RR_{pos}$$

$$[t]_x = VW\Sigma V^T \qquad t_{pos} = t_{pos} + tR_{pos}$$

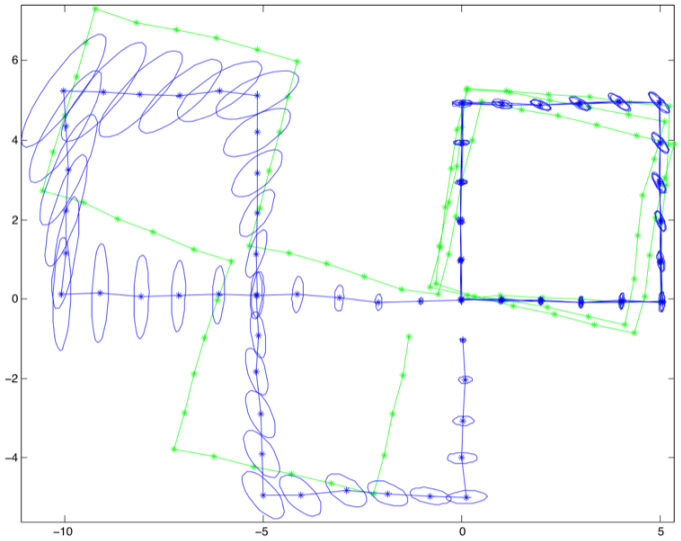
$$R = UW^{-1}V^T$$

Calculation of trajectory from essential matrix (estimated using RANSAC)

Project Overview cont.

Bundle adjustment is the process of further refining the trajectory estimate using optimization techniques.

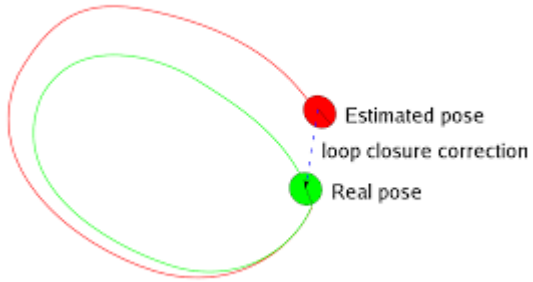
The sequence of poses is represented as a factor graph, connections were made at detected loops, and loop closure was performed.



Example bundle adjustment in GTSAM, green is the original and blue is the optimized trajectory

Context

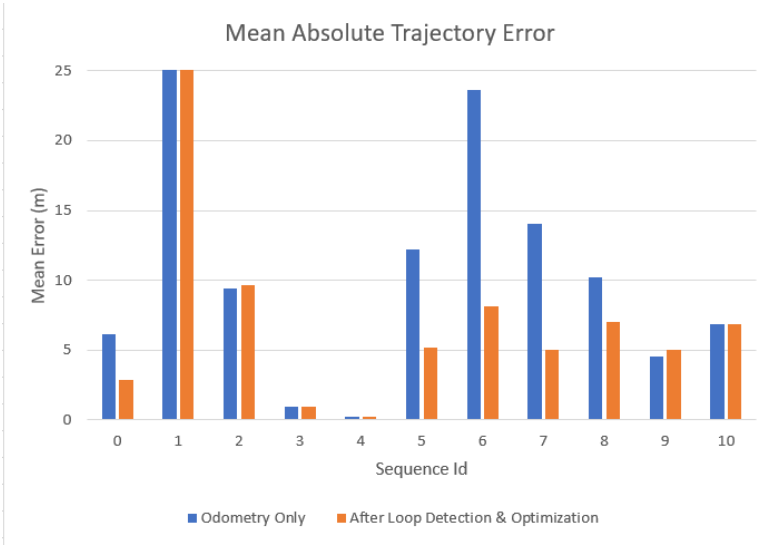
By combining loop closure techniques with visual odometry, a much more accurate estimation of the trajectory can be created compared to pure visual dead reckoning. This project integrated OpenCV for visual odometry and GTSAM for factor graph optimization.

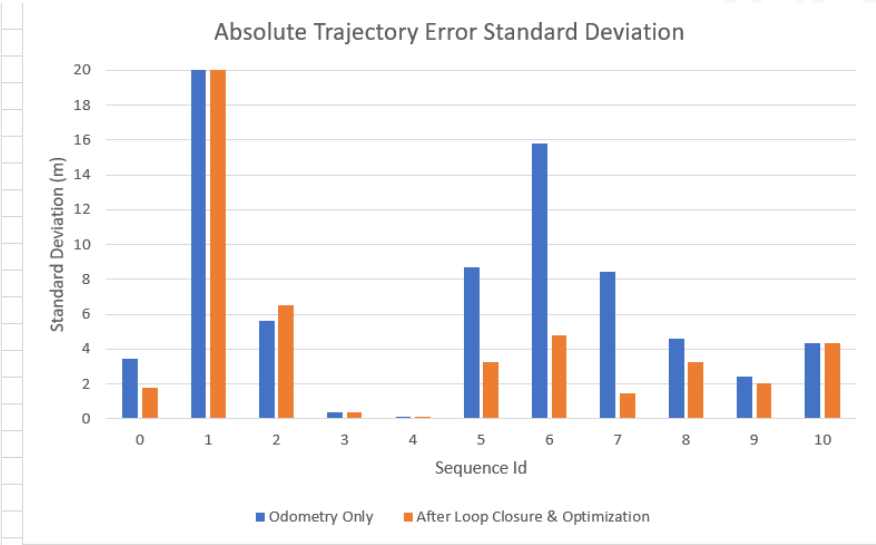


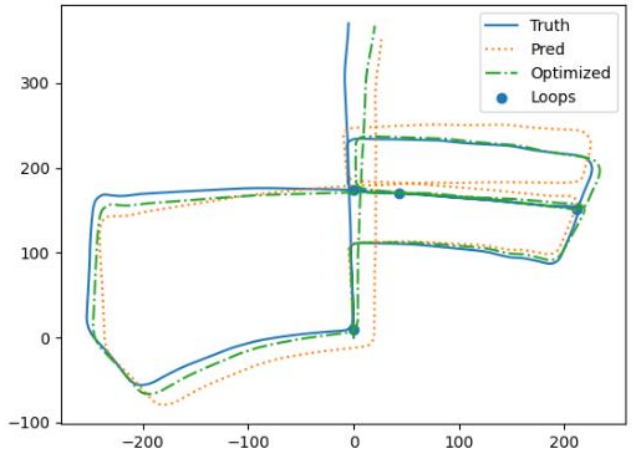
Example of loop closure enhancing an estimation

Project Outcome

- After integrating loop closure, I was able to reduce mean absolute trajectory error on the KITTI dataset by 23% and its standard deviation by 26%. With some examples of city driving trajectories completing in sub meter accuracy.
- The link to the GitHub repo of the project is: https://github.com/junqiwu02/monocular-odom







Optimized trajectory of sequence 1

Impacts

- This project demonstrated the viability of GTSAM for loop closure in a visual odometry pipeline
- While working on this project, I gained my experience working with OpenCV, computer vision techniques, and graph optimization techniques
- From this project, I also was able to develop my two NACE competencies: Career & Self Development and Critical Thinking