Vision based Collaborative Localization for Multirotor Vehicles

Sai Vemprala, Srikanth Saripalli

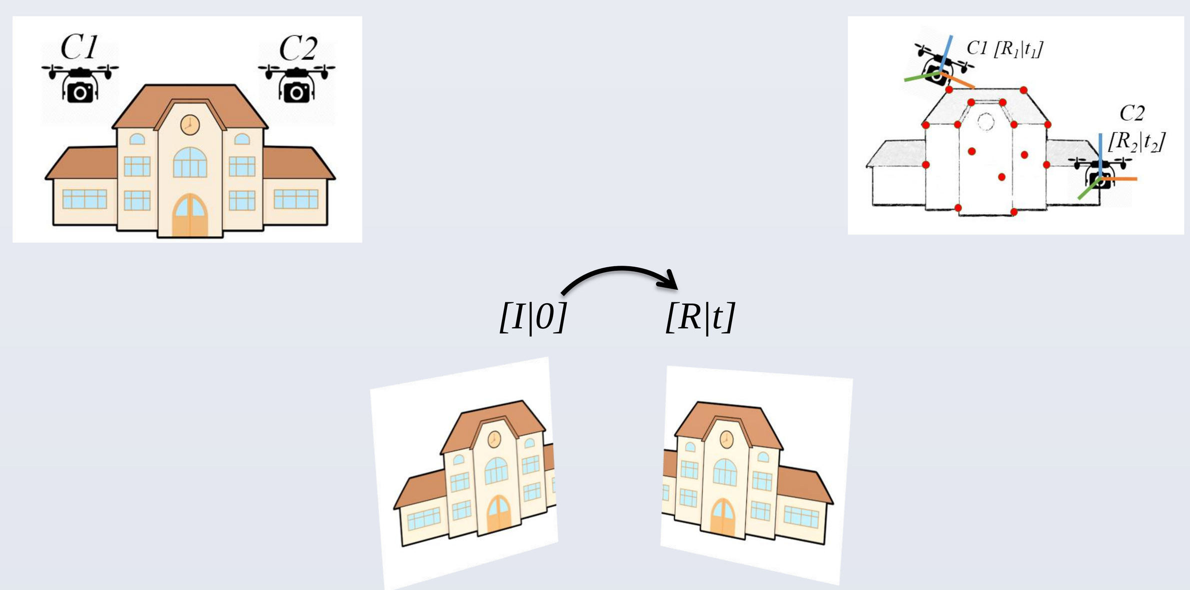
Autonomous Systems Technologies Research and Integration Laboratory
Arizona State University

INTRODUCTION

- We present a collaborative localization framework that can be used between multiple aerial vehicles each equipped with a monocular camera.
- Localization of two or more multirotor vehicles within a single group.
- Multiple view geometry adapted to MAVs for localization through changing environments, utilizing features visible from multiple vehicles.
- Mono cameras are cheap, light and almost ubiquitous on MAVs.

MOTIVATION

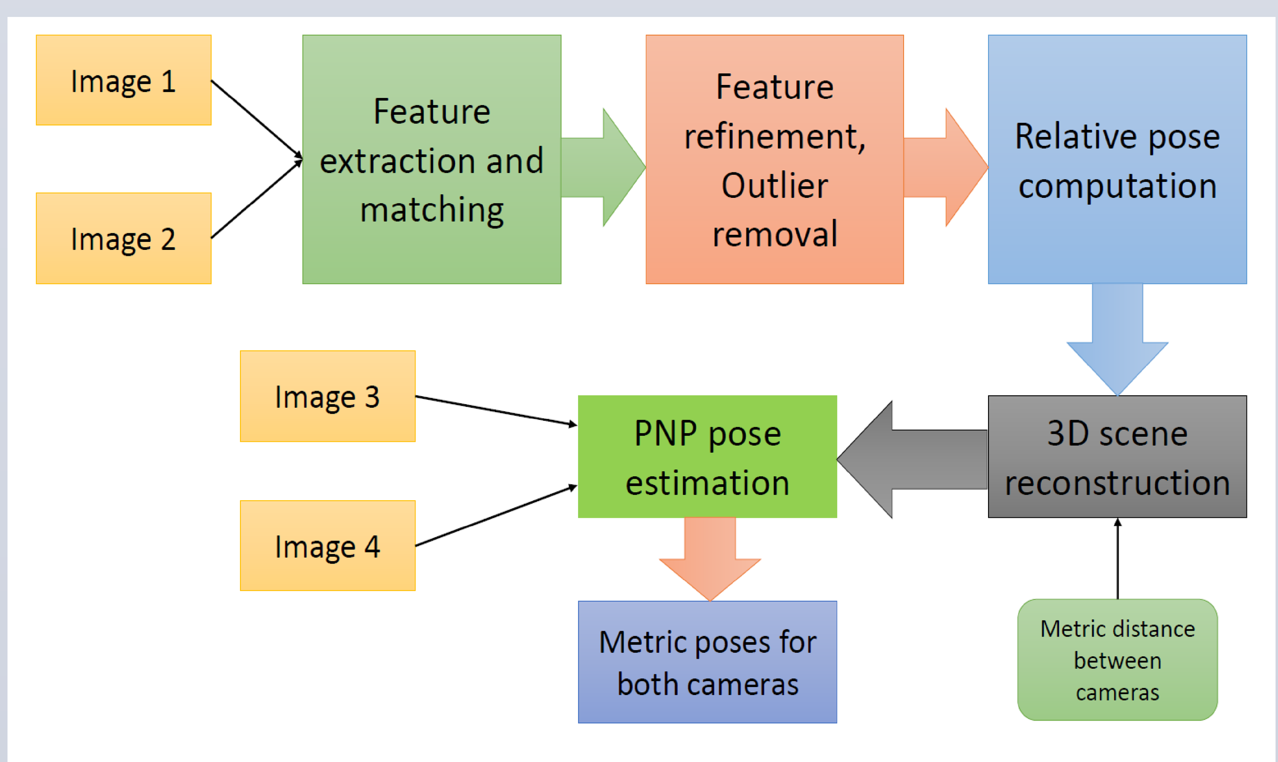
- In the context of swarms of UAVs, the focus is usually on small, lightweight platforms with limited computational capacity.
- Complex SLAM algorithms on each vehicle might not be feasible.
- Applying separate localization algorithms on each vehicle could introduce multiple sources of error independent of each other.



- Shifting focus from localizing vehicles individually to localization as part of a group with respect to each other.
- Collaborative localization is applicable for environments with no GPS, indoor-outdoor transitions etc.

ALGORITHM

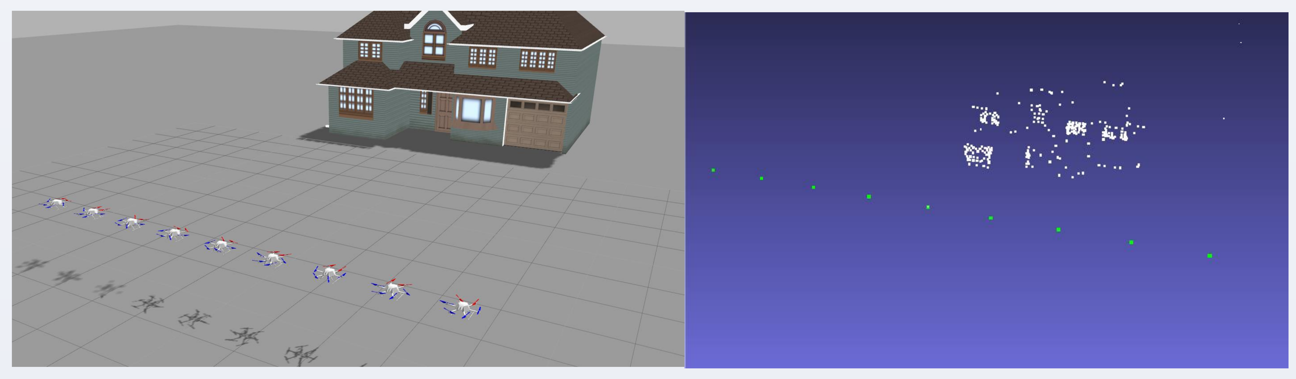
1. Scale and rotation invariant features are computed from scene, and matched.
2. Local difference binary descriptors and brute force matching are utilized to maintain accuracy but with a low computational demand.
3. We use the 5-point algorithm [1] to compute the first set of relative poses which is used to reconstruct the environment. An adjacency matrix connects features in case of more than 2 views (vehicles).
4. Features are then tracked between sets of images to localize the cameras at every capture using the 3D-2D correspondences (PNP) and bundle adjustment.
5. The environment point cloud is adaptively modified after certain ‘windows’ in time, depending on how fast things are changing.



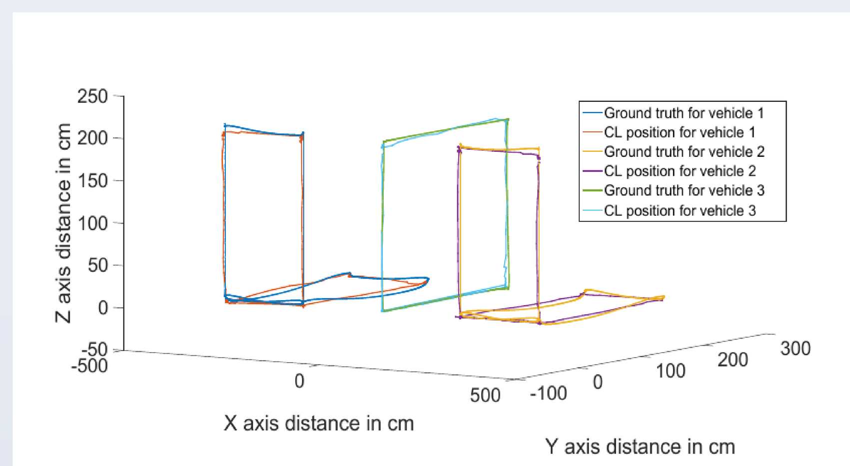
Robust outlier rejection of features through an ‘a-contrario’ RANSAC scheme, inspired by [2], that adaptively decides the threshold for the filtering so as to reduce geometric error, 3D-2D error.

RESULTS

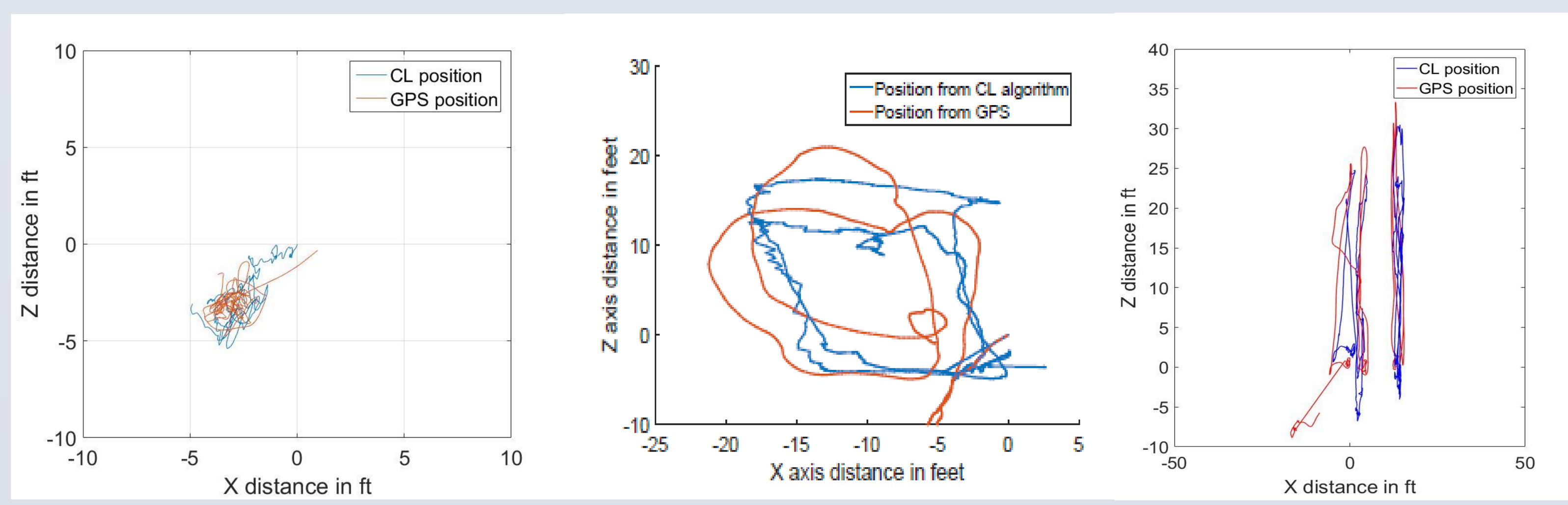
- Validation tests performed in simulation and using real flights.
- Localization algorithm run offline, an online implementation is in the works.



- Multiple vehicles were simulated in Gazebo and flown around in trajectories, compared with ground truth from the simulator. RMS errors were found to be in the order of 5-10 cm.



- Real flights involved cases where one camera was kept stationary as the other was flown on a quadrotor, as well as both cameras in flight.
- Image data was recorded onto onboard computers, later used for offline processing.
- Figures below demonstrate some results, with GPS position data for comparison



- Positions and orientations were found to be in accordance with GPS/IMU values, exhibiting less drift than GPS in some scenarios.
- Currently working on more validation tests.

CONCLUSIONS AND FUTURE WORK

- Our work deals with relative pose estimation between multirotor vehicles, in the context of localizing a group of vehicles with respect to each other.
- Initial tests involving simulations, one flying vehicle and two flying vehicles validate the algorithm.
- Future work involves speed improvements such as GPU acceleration, and subsequently an implementation in real time, which also involves development of a communication framework between the vehicles.
- Subsequently, we plan on using this localization in conjunction with a path planning algorithm for a group of UAVs.

REFERENCES

[1] Nister D., “An efficient solution to the five-point relative pose problem”, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 26(6): pp. 756–770, 2004.

[2] Moulon P., Monasse P., and Marlet R.. "Adaptive structure from motion with a contrario model estimation", *Proceedings of the 3rd Asian Conference on Computer Vision*, 2012.