Localization for Autonomous Vehicles

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1. Introduction/Context

*This research topic is part of the **NEMODRIVE** research group. Read the group profile first at: url.*

Precise and robust localization is a significant task for autonomous vehicles in complex scenarios. The accurate position of autonomous vehicles is necessary for decision making and path planning. This subject is constantly evolving, the sensors are becoming more and more accurate and the algorithms are more and more efficient.

We are currently integrating the Apollo framework and using the basic GNSS and IMU data for localization. This solution only offers a minimum of 3 meters accuracy for localization. Self-driving cars should be able to estimate their position with an error of less than 10 cm. Current neural network based vision algorithms can help us increase this accuracy only with monocular cameras. The first stage of research will be to improve current framework capabilities to navigate on UPB campus vector map only using the previously mentioned sensor setup.

The second stage of research will be to investigate novel methods which can precisely locate the position of autonomous vehicles based on the high-precision map ([5]) using the entire Nemodrive car setup: 3D-LIDAR, cameras, GNSS and IMU. Finally, experimental results will demonstrate the accuracy and robustness of the proposed method. Visual SLAM remains one of the areas of automated driving where CNNs are not mature for deployment in commercial automated driving systems. However, deep learning can be used to replace parts of the classical SLAM pipeline ([3], [4]). We will start from the Apollo Ego Localization module [2] and use knowledge from topics such as sensor fusion, Kalman filtering, Particle filters, robot modeling, machine learning to offer a position for our autonomous vehicle with a degree of accuracy to the best of our capabilities.

2. Objective

- Improve and evaluate on UPB campus a localization module that uses GNSS, IMU and 2D Camera data for an open-source autonomous driving platform.
- Deploy and evaluate on UPB campus a multi-sensor fusion localization method (GNSS, LiDAR and IMU).
- Build the UPB campus HD Map.
- Explore state-of-the-art full sensor ego localization algorithms and deploy a practical solution for a self-driving car on UPB campus.

3. Required and Learned Skills

- Requirements
  - Good knowledge of Python and/or C++
  - Practical grasp of applied mathematics (algebra, geometry) is a plus
  - Prior Machine Learning knowledge is preferred
  - Fast learner, proactive mindset
  - Comfortable working in a team
- Learned skills
  - Working with a complex autonomous driving framework (Apollo)
  - Practical experience with many of the technologies sustaining autonomous-driving
  - Experience in working with sensor fusion algorithms
  - Experience working with ML algorithms and practical deployment of deep neural networks
  - Experience working with frameworks such as: ROS, Pytorch, Scikit-learn, OpenCV, Pandas
  - Experience of contributing to the common goal of a large research team
  - Support and guidance for writing academic research papers

4. References

[1] apollo

[2] Apollo Ego Localization https://github.com/ApolloAuto/apollo/tree/master/modules/elo

[3] Milz, Stefan, et al. "Visual SLAM for Automated Driving: Exploring the Applications of Deep Learning." Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition Workshops. 2018.

[4] Heng, Lionel, et al. "Project AutoVision: Localization and 3D Scene Perception for an Autonomous Vehicle with a Multi-Camera System." arXiv preprint arXiv:1809.05477 (2018).

[5] Seif, Heiko G., and Xiaolong Hu. "Autonomous driving in the iCity—HD maps as a key challenge of the automotive industry." Engineering 2.2 (2016): 159-162.