Self-Driving Car Localization Competition

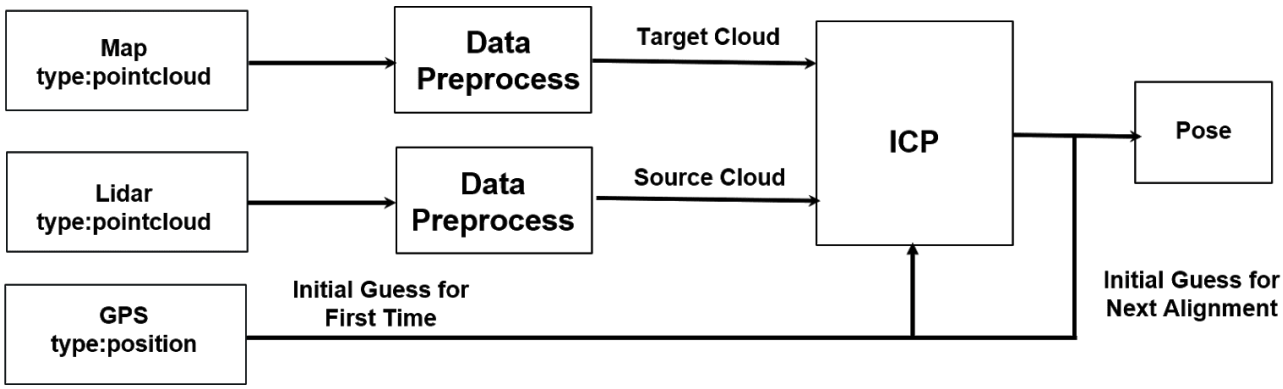
Team BNN:

Sheng Cheng Lee

Jung Han Chen

Chao Chun Hsu

System Framework



Personal Contribution

- Sheng Cheng Lee
  - ICP Implementation
  - Map Ground Removal
  - Determination of Initial Orientation
- Jung Han Chen
  - EKF
  - Result Visualization
  - Fine Tune
- Chao Chun Hsu
  - Car Removal from Lidar Scan
  - Result Evaluation
  - Fine Tuner

Our Attempt and Result

• Map Ground Removal

When we are working on the nuScenes dataset, we found that the map quality is not as good as it is in ITRI dataset and this may cause huge effect on the localization result. With this given map, we then came up with the idea of improving the map points with some preprocessing before doing localization. We didn't wave much time so we only tried to remove the noisy, not uniformly aligned ground points in the map by calculating the normal vectors and select those with horizontal normals. The results shows that, after the ground removal procedure, the aligning can usually get better score. However, we also found that we can easily get lost in z-direction, which is obvious that without the information of ground, our approach losts its reference to z-direction.

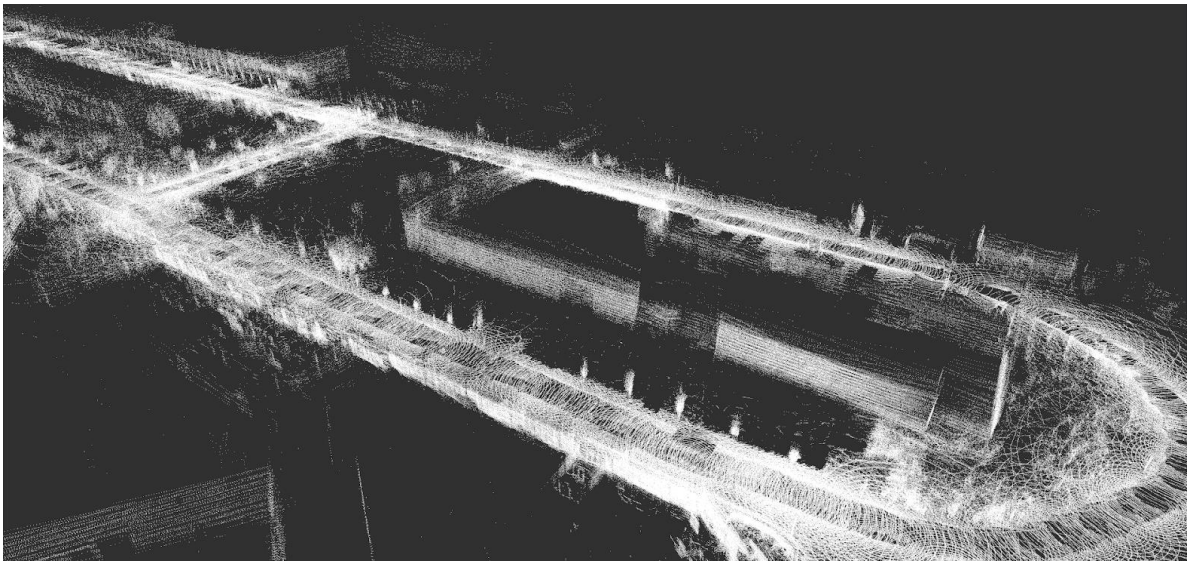


Figure. Map Cloud with Ground Points.

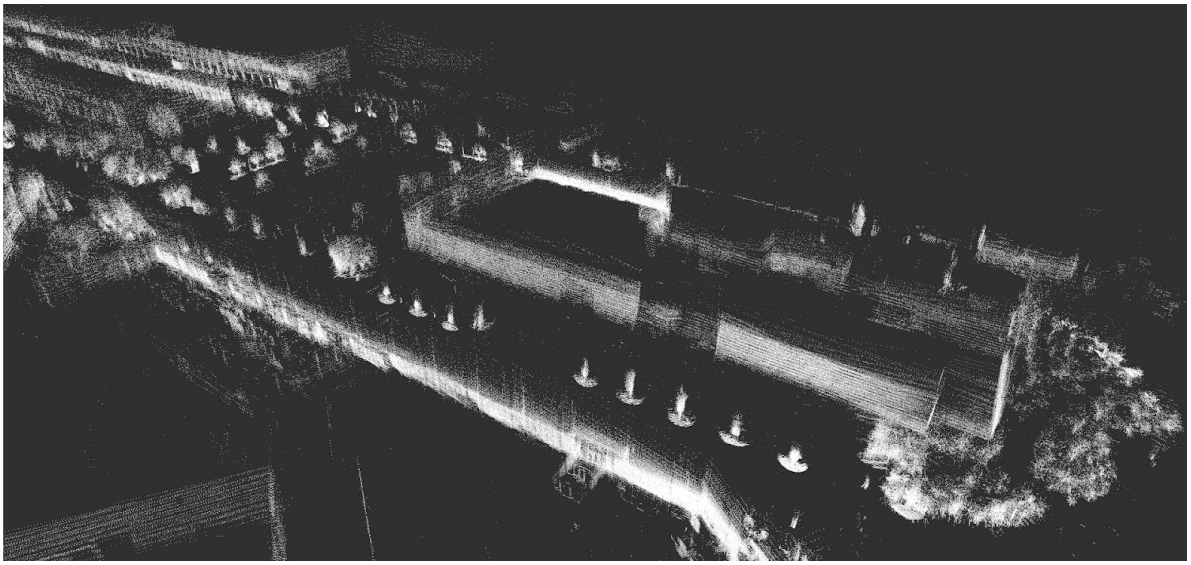


Figure. Map Cloud with Ground Points Removed.

Our Attempt and Result

• Lost Recovery from GPS

Basically, we didn't use GPS a lot. After the first guess of ICP using the GPS as initial translation, GPS has only been used to detect if there is too much error between ICP result and GPS measurements. Here's how we get it implemented. In every iteration of point cloud input, we check if the result after the alignment is too far from the GPS measurement. If there is an error larger than, say 3.6 meter, we guess the pose with GPS as translation and try to find the orientation again.

• EKF Fusion

The ICP method sometimes may drift because of some outlier like cars and trucks. The problem is more serious in nuScenes data. We try to use the EKF to remove some noise and smooth the pose of car fusing with the IMU data. The picture shows that we use the EKF in the ITRI data. The performance is not obvious, because the result we only use ICP is good enough. However, when we try to use EKF in nuScenes data, it don’t work. We think the EKF has to be adjusted by setting the covariance.

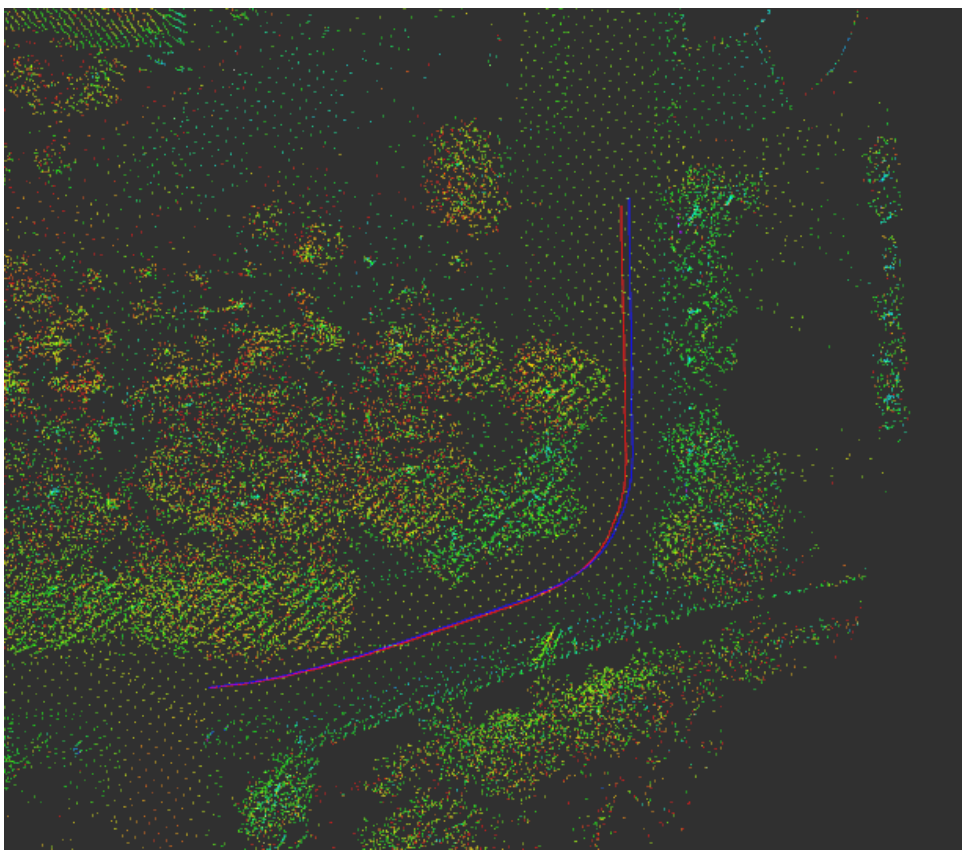


Figure.
Blue line represents for pose from ICP.
Red line represents the pose through the EKF.

Our Attempt and Result

- Car Removal

Due to the point cloud in the map includes some other objects on the road (e.g. experiment car, cars pass by, cars dock on the roadside, etc.) We want the localization be more precise, we found the topic called "/lidar_points", recorded by the experiment car.

- Determination of Initial Orientation

For a long while, we thought that the IMU orientation is already transformed onto the map frame, which means we can use it as the orientation of the first initial guess. In ITRI public dataset, this luckily works good. But, this actually is wrong. Finally when we figure out how come our code can't work in other private dataset, we come up with a method to find the first orientation given a nearby GPS measurement. Firstly, we set GPS data as the translation of initial guess. Later, several times of rotation has been implemented to find out which direction does the car face. Initially, we found that some orientation may perform better score than the real orientation, which makes us frustrated. However, this method is eventually proved to be feasible by limiting the error function to only add up errors within smaller distance. In result, we spent a lot of time finding the first pose, but it shows that this method works pretty well.

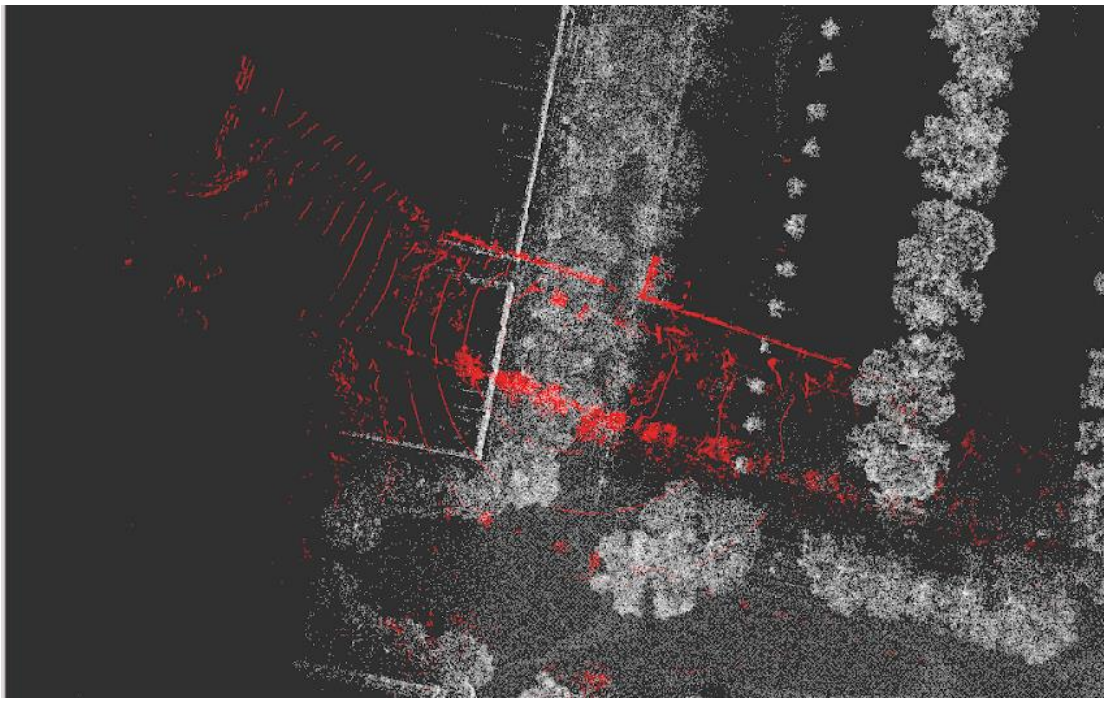


Figure.
Our System Trying to find the proper orientation
to start going

Conclusion

In this competition, we spend a lot of time figuring out the usage of ICP, including the system workflow, transferring between frames, and even parameters of the aligning procedure. Throughout the competition, we found that ICP performs good when your map (target) and lidar scan (source) are both clean and not noisy. As the map comes with some noise or not aligned points, ICP is easy to get confused. It is an important issue for us to deal with the noise, our approach tried some method such as Kalman Filter, Ground Removal, Spatial Segmentation, etc. At the end, we didn't get much improvement on the localization result. However, these practice did give us some insight of localization system. We have a lot of fun coding the system and having interesting discussion trying to solve such problems.

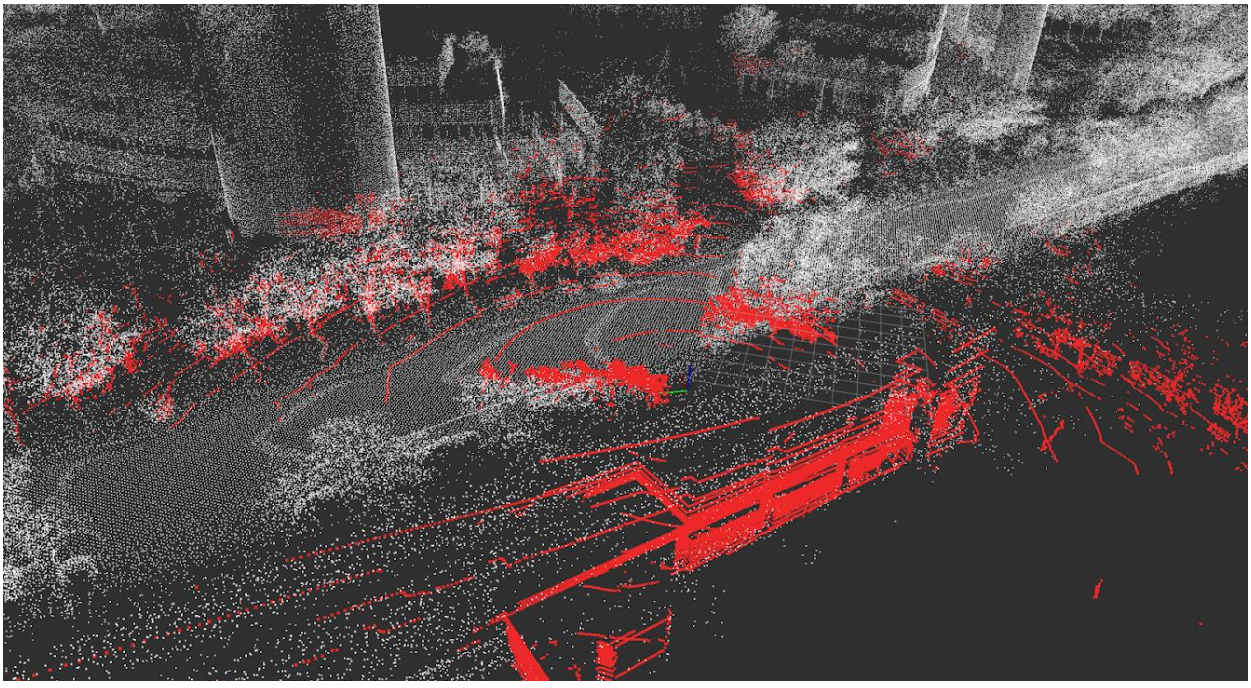


Figure.
System Localizing in ITRI.