ILR11

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Team E: Wholesome Robotics
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Date: November 18, 2019

Team Progress

The team is focused on getting ready for Fall Validation Demonstration. The two major aspects of the project, namely the monitoring and the navigation pipeline are the focus right now.
The monitoring pipeline is complete i.e. with the input as the rosbag collected by the robot, geotagged images are extracted. These images go through the inference pipeline which labels if the plant in the image is infected by disease or has holes in it. Then this labelled data goes to the visualizer pipeline where they are presented in a graphical manner to the user. The visualization is interactive and clusters the plants so that it's easier to understand the location of disease and pest pressure, the user can access each clustered labelled data and change the label and also add notes to the image.
On the navigation pipeline front, we are trying two separate approaches. In the first approach which is being handled by me, we are using two Kalman Filters to fuse data between IMU, RTK GPS and Visual Odometry using the robot_localization package. In the other approach we are using Lidar point cloud to detect the rows of plants and use that to estimate the orientation of the robot and its offset from the center of the row. This data is fused with the visual odometry data in the particle filter to provide an estimate of the robot's position. Both packages have their own advantages and disadvantages, the EKF fusion's performance is independent of whether the robot is in the row or outside it. The particle filter on the other hand is GPS denied which is great, however its estimate is not good outside the plant row. We are currently pursuing both the methods and will stick to the one which gives a better performance in the end. Currently both the methods are not performing well, the particle filter is able to autonomously navigate a single row but is unable to switch to the other row, the EKF has some bugs which gives an inaccurate transform which will be covered in the challenges section of this report.

Individual Progress

I have been focusing on the Kalman Filter based fusion, previously I was able to get the entire pipeline to work. However, the estimate from the filter was quite inaccurate. This inaccuracy was attributed to improper sensor covariances and also initial covariance of the filter. I debugged the issues by testing the various factors of the filter like sensor orientation, time sync issues between the various sensors, estimating the covariance of the sensors by collecting data, its mean and its covariance. The filter was also tuned on a rosbag before the field visit and seemed to perform well. However, during the field visit the performance of the filter was not acceptable.
The performance of the filter was attributed to two major factors the alignment of the trajectory generated in the map frame and initial covariance values in the filter.

To understand the challenge faced, a better understanding of the various frames is required.

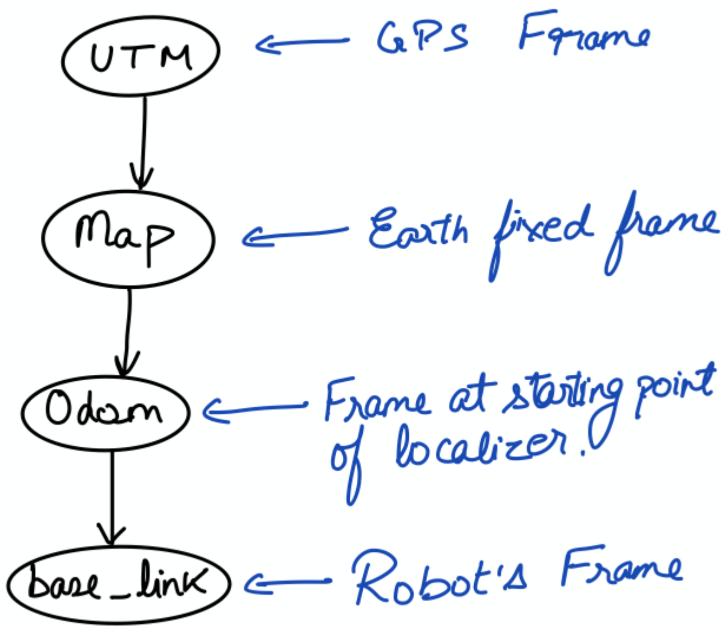

Figure 1 Various frames in the filter and their ideal tree structure

Here the UTM frame is the point at which the sensor output from the RTK GPS will be zero. This is an earth fixed frame. The RTK GPS provides as output the position of the GPS antenna in this frame. The map frame and odom frame both start at the point where the robot localization is started. The map is an earth fixed frame and does not drift whereas the odom is not earth fixed and moves if the odometry estimate of motion from the starting point is inaccurate. Base-link is the robot's frame.
The local fusion outputs the odom to base transform and the map to odom transform is published by the Global fusion which fuses RTK GPS also apart from other sensors.
The discrepancy between the two fusion processes is handled by the map to odom transform.
Apart from the two fusion nodes, a third node called navsat_transform_node is used, which transforms data from UTM frame to map frame so that the Global fusion can fuse the data.

In our case, we save the map as a set of waypoints recorded in UTM frame. During the previous field visit, we assumed that the map frame was at the starting point of the first row, aligned along it. However, realistically it is difficult to align the robot to the correct orientation and position before starting the localization. This causes the robot to believe that the generated trajectory is rotated/moved making it go through the plants. This issue is further discussed in the challenges section.

Challenges

1) In-accurate UTM to Map transform

The navsat_transform_node apart from transforming GPS output to map frame also publishes the UTM to Map transform. However, it is not publishing this transform on the robot. This was verified by visualizing the TF - tree of the robot. I spent a lot of time trying to debug this issue, I verified the package documentation to ensure I was using the right settings, I checked all sensor outputs to ensure that all sensors were providing data. I even consulted Micheal Fan from team SureClean who used the same package on their robot, but we could not debug the issue. During one of this process, I realized that if I echo the transform, it shows that the transform is being published at time 0.00 and not after that. Thus, the nodes are not able to lookup this transform. However, they are able to lookup UTM to Base_Link and Base_link to Map. So, I decided to approximate the UTM to Map transform by inverting these transforms. Although these are collected at different times, they should still be quite accurate. However, during the field visit I observed that this transform was itself noisy/inaccurate. Thus, either the navsat_transform node is not working well or the transform variation within the time difference when UTM to base_link and base_link to map are calculated is quite high. This will be investigated further this week utilizing the data collected during the field visit. I will also look into writing a custom navsat_transform_node if the root cause for the issue is identified to be that node.

Teamwork

Aaditya:
He is working with John to implement and tune the Particle filter.

Dung-han Lee:
He is improving the performance of the inference pipeline by training the models on the data obtained from the labelling service.

Hillel:
He is handling purchasing right now and is available to help others as his visualization pipeline is complete.

John:
He is working with Aaditya to improve the particle filter and is handling logistics for field visit.

Future Plans

Team:

Improve Monitoring MVP
Complete Navigation MVP

Individual:

- Tune the robot localization package