INDIVIDUAL LAB REPORT 7

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Wholesome Robotics, Team E

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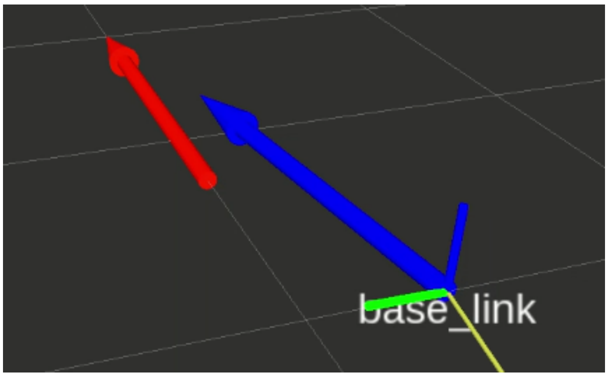

Figure 1: RTK localization in the map frame. The red arrow is the desired pose for the pure pursuit controller and indicates the position and orientation of the center of the row.

0.1 Individual Progress

I implemented code to extract a 2D line representing the first row of the Rivendale farm from the October 2019 dataset. According to our plan, our map is a array of 2D lines representing the rows. So therefore, this line was taken as the map for initial testing.

I wrote a class `GpsHelper` is instantiated with a map of the rows in UTM coordinates. It uses this map to then transform robot GPS positions into the map frame. It also takes the GPS link to base link transform as a parameter to the constructor in order to correct for the roll of the robot. The RTK GPS is mounted high from the ground, about 1.8 meters, and the robot wheel track is very narrow. As a result, when the robot travels over bumps there can be significant rolling of the robot. With these dimensions, a roll of five degrees would change the lateral position of the robot by 15 centimeters. Therefore roll correction is necessary. For an initial implementation, I used the orientation coming from our IMU.

I also implemented an RTK navgiation node which uses `GpsHelper` and subscribes to the IMU messages and GPS messages. It publishes the position of the robot in the map frame, which was previously done by the particle filter.

0.2 Challenges

The roll correction does not appear to improve the accuracy of the localization. Actually, it seems to add additional noise.

Roll correction requires knowledge of the yaw of the robot in the global coordinate frame as well as the roll and pitch. The yaw in particular can be hard to estimate due to

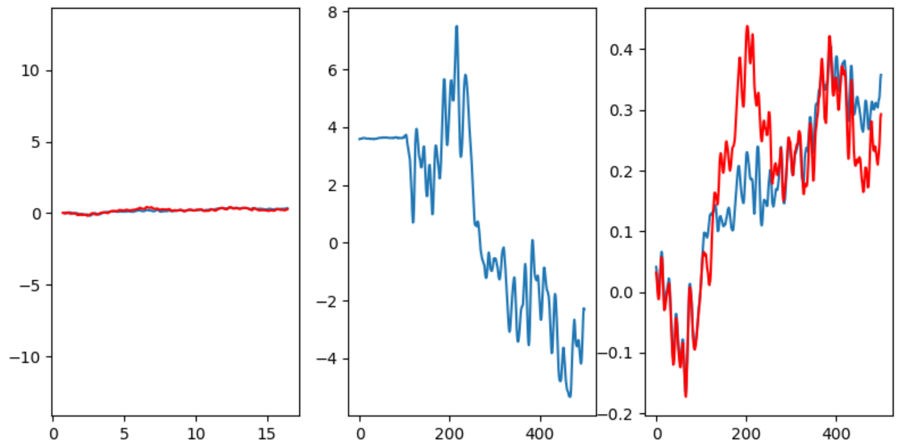

Figure 2: Left: A bird's eye view of the path taken by the robot down the row without roll correction (blue) and with row correction (red) for the first 500 timesteps. Middle: The roll of the robot over the first 500 timesteps. Right: The Y-deviation of the localization of the robot from the center of the row without roll correction (blue) and with roll correction (red)

the inaccuracies of the magnetometer. It is not clear whether the source of error is error in yaw or error in roll or pitch or the transforms themselves. It is clear, however that the motion is impossible since our robot cannot translate sideways, and I expected for the roll correction to remove any lateral movement, not cause more problems.

The field test itself on Friday was unsuccessful, as we stopped the test when we heard electrical popping sounds and saw sparks coming from our robot. We were not able to collect data. After debugging, we found that the source of the issue was an exposed bolt on the battery cabling which shorted against the frame of the robot. We have since taped over it with electrical tape, tested the robot, and feel comfortable testing again tomorrow.

0.3 Teamwork

1. Hillel: Integrated UI for visualizing plant health
2. Aaditya: Integrated UI for visualizing plant health, investigated exposure correction
3. Aman: Cleaning up of planning controls code
4. John: RTK localization, roll correction
5. Dung-Han Lee: Plant health perception generalization to 4 pl ants evaluation

Figure 3: The weed suppression nets installed on the farm.

I collaborated with Aman to integrate the controller with the new RTK localization node. I also discuessed the API for the texttttGpsHelper so that it could be re-used in the plannning controls code. I collaborated with Aman, Hillel, and Aaditya to get the Zotac computer and ZED computer set up again on the robot, so that we can collect data at our field test tomorrow.

0.4 Plans

My current focus is to fix the lateral movement issue. I plan to meet with Grant the TA to learn about his experience in solving a similar problem. The first step is to isolate the source of error. I would like to find out whether the errors are correlated with roll or yaw. (The robot basically does not yaw.) I can do this by comparing what happens when I set each component of the rotation to zero. If yaw is the problem, some research also revealed that some GPS units have multiple antennas and using RTK correction with these can result in very high accuracy yaw estimates.

I spoke with Tim who previously worked on navigation for the robot and mentioned that they estimated heading by assuming the robot is traveling straight down the row and computing the heading by smoothing the direction traveled by the robot in the recent past. I plan on reading through the code for that approach and potentially incorporating those changes. However, Tim warned me that their RTK navigation never really worked reliably and that reliable heading estimation was still an issue when he worked on the navigation.

I also plan on evaluating the existing row detector and particle filter on data collected from the farm this year. The farmers have laid down weed suppression nets which make a much more uniform ground surface and seem to create a more obvious separation of the rows and the center line. The plants themselves also have been planted much more uniformly which may enable easier navigation.