INDIVIDUAL LAB REPORT 4

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Wholesome Robotics, Team E

Teammates:
Aman Agarwal
Aaditya Saraiya
Hillel Hochsztein
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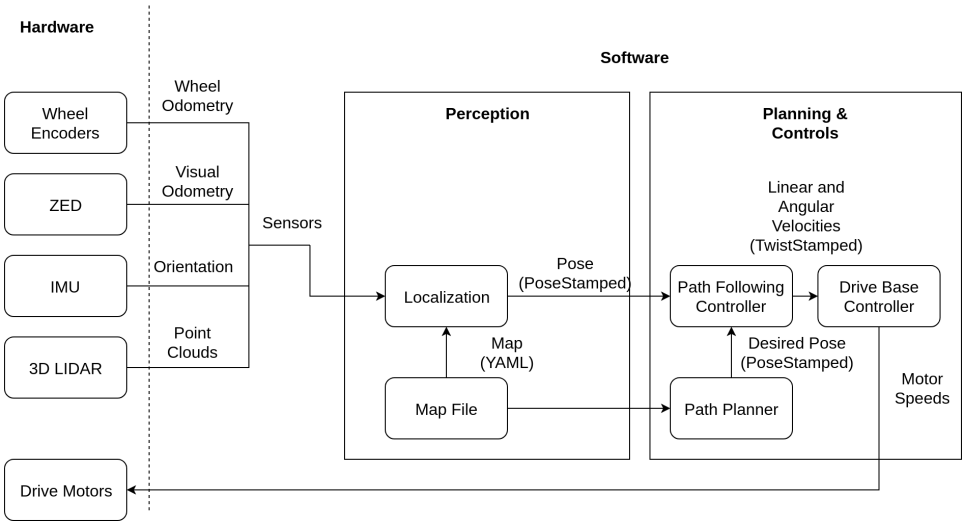

Figure 1: Updated navigation architecture with ROS message types.

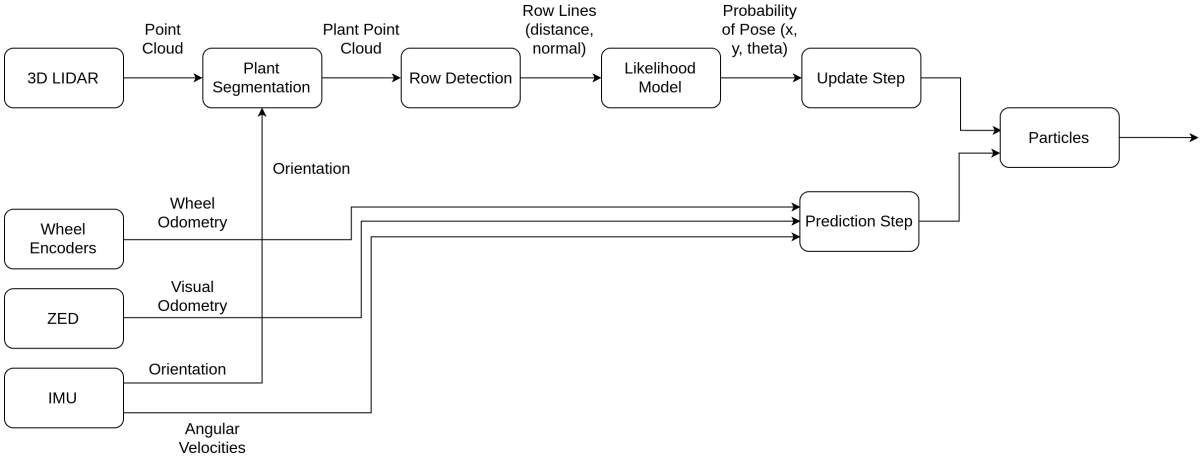

Figure 2: Expansion of the localization subsystem in detail.

0.1 Individual Progress

I have gotten the team on board with taking a new approach for navigation. Instead of doing SLAM to generate a map in which we will be localizing, we will be directly predicting row line position and orientation from point cloud data and fusing this with other sensors to localize. I've drawn out block diagram architectures for the components and divided up work among myself, Aaditya, and Aman in order to implement this. I've implemented an initial row detector using a line fitting approach in anticipation of our first integrated test of the system this Sunday.

Special care has been taken in order to make the architecture very testable and extensible. The architecture has been designed so that we can have a separate "fake segmenter"

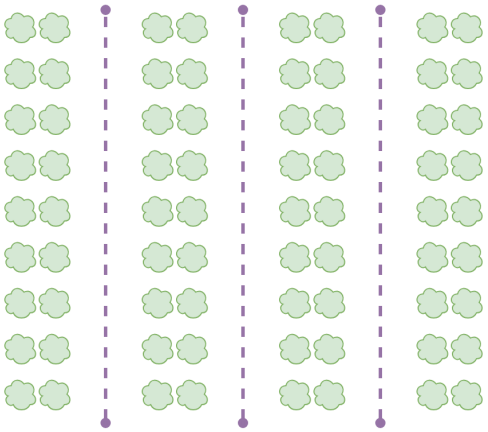

Figure 3: Illustration of the map for the new approach.

which only cares about height, not plant appearance, so we can test the path planning and controls on the robot on-campus with traffic cones in place of plants. We can learn the plant verses ground segmentation from data, validate it on data, and then subsitute the more robust learned segmenter for field tests. In addition, we can substitute our localization node with a localization node based on RTK GPS data as a fallback in case our localization node does not work in time for the SVD.

0.2 Challenges

Finding the right balance of functionality and simplicity for the navigation strategy has been a challenge. We originally aimed for a pipeline in which a SLAM system outputted a fully registered and geometrically consistent pointcloud which would be used to fit a Gassian Mixture Model. The reasoning was, modeling every leaf exactly is not practical, because plants grow and change over time, and doing ray-casting with something complex like plants would be computationally intense. Instead, modeling the probability of observing a point on a plant could be drawn from a Gaussian distribution with a mean at the center of the stalk and a covariance corresponding to the spread of the foliage of the plant.

In practice, getting this pipeline to work accurately and in real-time was challenging, and there were concerns about how accurate this model would be as plants grow over time. We decided to abandon this approach in favor of an approach where the map representation of the farm is simply the lines where the robot may drive down the row. A perception module would observe lines of crops and fuse this with visual odometry to

localize the robot. The current challenge is to get this system working and function for the spring validation demo.

Additionally, finding the right balance of on-campus testing (without a field), rosbag testing (playing back a bagfile and comparing outputs to ground truth), and in-field testing has been a challenge. Field testing is time consuming and requires renting a van to drive to the farm, but is required to make sure the robot will work in the intended environment. On-campus and rosbag testing is easier but there exists the risk of creating a system which works well on campus and not in the farm environment. I am keeping this balance in mind throughout our testing.

0.3 Teamwork

The current breakdown of work is:

1. Hillel: PCB design and weeding manipulator
2. Aman: Sensor mounts and path planning
3. John: Row detection
4. Aaditya: Sensor fusion
5. Dung-Han Lee: Plant health perception

I have been collaborating closely with Aaditya concerning how to fuse my row detection with his sensor fusion module. I've also been collaborating with Dung-Han concerning what metric to use for the plant health, since there have been issues trying to achieve our performance targets with metric based on the diseased leaf area divided by the total plant leaf area. Aman has now shifted some of his work to the software side in terms of working on planning, so I have also been collaborating with him as well regarding the path planning component of the new navigation approach. I've also been collaborating with him regarding the sensor mounts and how that fits into our navigation strategy.

0.4 Plans

I currently am planning to improve my row detections by learning the plant versus ground segmentation from data. While height-based segmentation is easy and works well, it has

issues in some cases where there are many weeds. I may have to adapt based on the results from the test this Sunday.