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Summary

We decided our task and goals of our papers this week. And also we divided our roles of who will take charge of a certain task, and started to make a small demos.

We're planning to make a car which can ride autonomously outdoors. SLAM, Lidar sensor, GPS and mechanical car building will be included.

What FarmVroong completed this week:

- Made the roadmap of the project

  At first, we had no idea of what kinds of work the car has to do on the farms cause we didn't know about the life in the farm. Professor Smith suggested about "Leader-follower System Car" which can carry logs or tools while the farmer is at work. If we use "Leader-follower system", vision tracking or radio transmitter system would be the main problems that have to be solved.

  After several discussions, we thought about "How can the car return to the home if it got full?" and reached a consensus on doing outdoor SLAM. We thought this project can be ideal to deal with Lidar, GPS, cameras, and the outdoor environment.

  So this week we searched the basic algorithms of SLAM and Path planning, tested sensors, and settled up the developing environment at the ubuntu computer and raspberry pi. Also, we broke down the cars (John Deere tracker for kids - Doctor Matson suggested using the toy car so we don't have to make our own suspensions or brake pads) and reconstructed them.

- Testing Lidar

  We checked that the Lidar works well and visualized the data with Rviz.

  RPLidar Raw Data showing on Macbook Terminal [5]
  RPLidar data on Ros Rviz [4]

- Settling up Raspberry Pi

- Reconstructing John Deere tractor

  We began to make a demo car using the John Deere Ground Force product of Peg Perego Inc. By referring to the manual [6], we checked the overall structure and parts of the car and removed the unused parts for driving. So, we left main frame, tires, steering system, and electronic system. Out of these, the steering system is original to be controlled manually. Therefore, we added a servo motor to control the steering system. However, the motor doesn't have enough power, so we added a gearbox and additional frames.

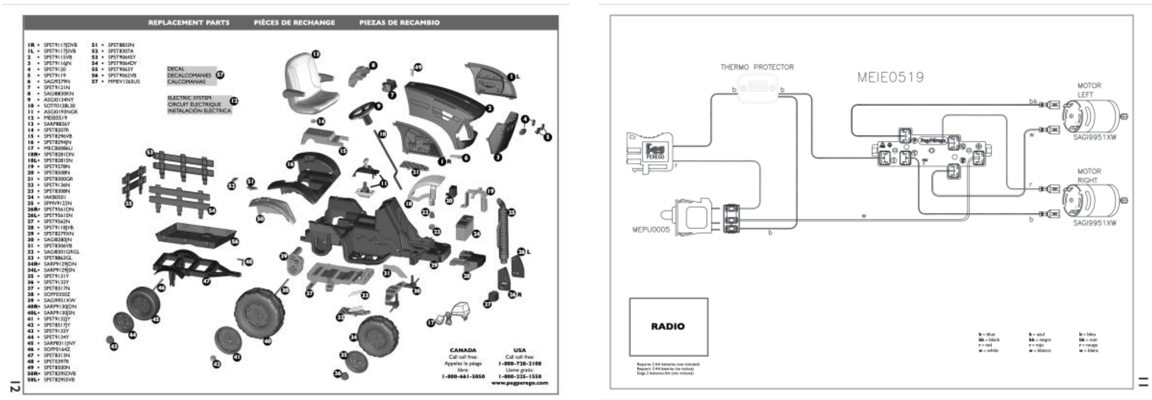


Fig. 1. Replacement part and Electrical diagram of the tractor.

Fig. 2. Reconstructing John Deere tractor to make a demo car

- Decided which sensor to use

  We compared the pros and cons of the sensors: Radar, Lidar, ultrasonic sensor, and Camera. Conclusively, we decided to use Lidar, an ultrasonic, camera, and GPS sensor for our task, which means we aim to make a multimodal self-driving vehicle(SDV).

  - Radar

    Radar is good for detecting and tracking objects in any conditions of light and weather, due to the long-range and doppler function.

However, the radar performs badly when it comes to nonmetal objects. As we aim to do SLAM at the farm, which has lots of nonmetal objects, such as grass and trees, we decided not to use radar for our task.

- Lidar

Lidar uses a pulse laser in contrast to radar, which uses radio wave. Thanks to the attributes of the laser, lidar provides high resolution and can detect nonmetal objects. Therefore, we decided to use Lidar for SLAM in the outdoor environment, farm. Meanwhile, there are disadvantages that lidar is expensive and vulnerable to the environment, such as fog and dust.

- Ultrasonic sensor

The ultrasonic sensor has lots of advantages. It is robust to the weather and environments. In addition, it can detect nonmetal objects. Also, it was very cheap. However, its resolution is low and the range is short. Critically it is vulnerable to the high-frequency sound, which may easily occur on the farm. Therefore, an ultrasonic sensor can be a good assist.

- Camera

Camera can collect the broadest range of frequency, including color data. Therefore, the camera is used well for vision deep learning tasks, such as object detection and semantic segmentation.

We decided to use the camera for detecting obstacles. So we are planning to buy the camera, which has a wide Field of View(FOV), and high resolution, and USB port for sending data.

However, there are disadvantages, too. Unlike Radar, Lidar, and ultrasonic sensors, the camera is a passive sensor, which doesn't shoot anything. Therefore, the camera is vulnerable to ambient light and weather. Conclusively, we decided not to use the camera for SLAM, but for detecting obstacles.

- GPS sensor

AS GPS uses absolute positioning, it doesn't have accumulated error. Moreover, it's very cheap and works well at outdoor, which doesn't have any barriers above. Therefore, we decided to use a GPS sensor for our task.

However, there are anticipating bad effects, which its accuracy is about 1 to 3 meters when using public GPS base station. Therefore, we are going to try Differential Global Positioning System(DGPS) or Real-Time Kinematic GPS (RTK GPS).

- Outdoor SLAM

We try to find out how to use SLAM with Lidar, Camera, and GPS. We searched the papers and books and then summarized the methods.

1. Real-Time Hierarchical Outdoor SLAM Based on Stereovision and GPS Fusion [2]

They use the Extended Kalman Filter(EKF) SLAM [3]. However, using the EKF SLAM in outdoor may has a limitation that introduces computational overhead. For this reason, They try to fix the EKF SLAM. At first, we had an experiment with the EKF SLAM. The result is good, but it takes a long time to get the output. So we will change the algorithm to reduce the computational burden and get good results.

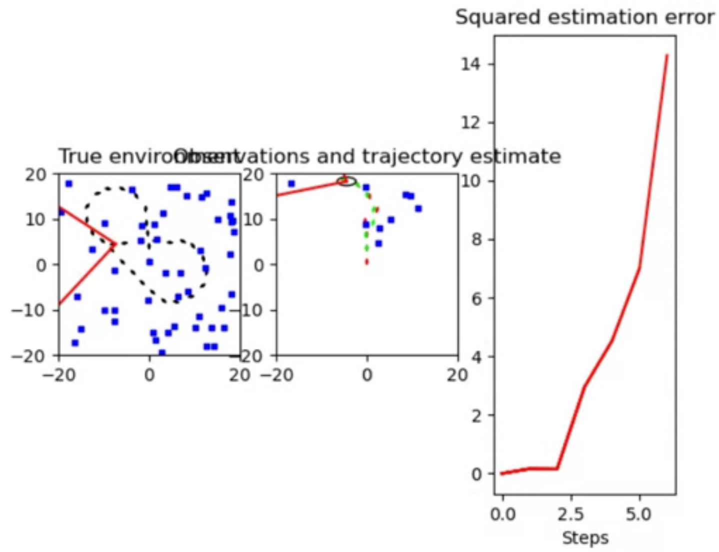


Fig. 3. Generating the global map with EKF SLAM.

- Camera

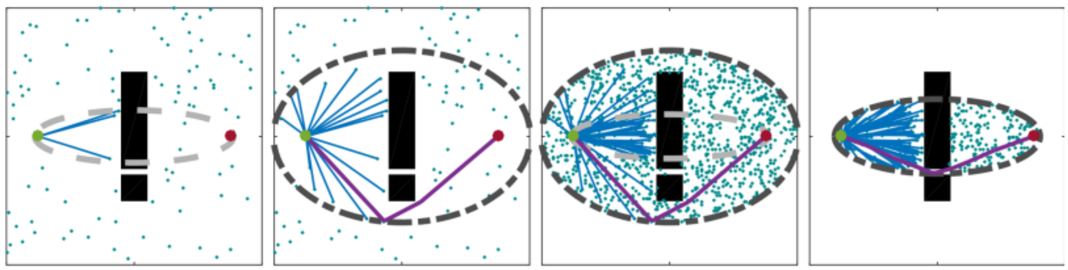
They use SIFT to find the landmarks. The EKF SLAM usually set the landmarks randomly, but this may disturb making the global map. For this reason, they try to use the SIFT which is to find out the feature in the image and match the point of the feature. This can help to find and compare the landmark. However, compared to SURF, SIFT has more computational complexity. Reducing the computational complexity is an important part of the Outdoor SLAM, we thought that using SURF may be better than SIFT. We will do the experiment on it.

- GPS

They use GPS to update the local state helping the localization and covariance estimations. If the GPS is unstable, they only use the camera to make the map. We are going to use this concept in our project to use the GPS for mapping.

- Path planning

We found the most suitable method for path planning. There are two different ways of the path planning, which are graph-based searches and sample-based planning. Graph-based searches are more accurate than sample-based planning, however, it takes a lot of time to get the result and has a computational burden. Sample-based planning is more simple than graph-based searches and also has a good results. For this reason, we decided to use sample-based planning, and we found BIT * method [1].



The search of a batch expands outwards from the minimum solution propsed by a heuristic.

(a)

The search stops when a solution is found or the batch of samples has been completely searched.

(b)

A batch of new samples is then added and the search resumes from the minimum solution.

(c)

This process repeats indefinitely, focusing both the approximation of the domain and its search.

(d)

Fig. 4. The example of the BIT * method

First, Select the nodes and find the path to the goal by heuristic

Second, If the path exists, stop to find the path and make the new batch of the sample without considering any states outside the informed set it defines.

Third, Keep searching and when an improved solution is found, stop searching.

Last, Repeat it.

- Vision detection

When driving an autonomous car, detecting the obstacles is the most important work. Driving the autonomous car on the farm and forest, recognizing the object which can be passable or not is an important task. For example, Fallen trees or long grass will be the obstacles for the car, the short grass will be the passable object. However, it is hard to recognizing the objects is difficult. Using the Convolution neural network (CNN) to detect the object may be impossible, that is because the datasets are insufficient. We try to use edge detection and detect the tree for the edge, however, the result shows that the edge is not clear to detect the object. Figure 5 shows the result of the edge detection. We have to find other methods which can be simple and effective to find the obstacles.

Fig. 5. The result of the edge detection with Canny edge detector.

Things to do by next week

- Making the little car move as the computer commands.

  Doctor Matson said that we have to decide what is the **agent**'s roll and how the **environment** will be. And also he told us to break down the goals into smaller tasks. So next week , we are aiming to make a car that can avoid obstacles and make the map of the first floor.

- Choose which SLAM algorithms to use and simulate it with Gazebo

Problems or challenges:

- Nvidia Jetson TK1 Setting

  Nvidia Jetson TK1 Setting At first, I started to set up the robot developing environment on **Raspberry Pi 4 Model B** for there are plenty of them downstairs. I installed ubuntu 22.04 Jammy Jellifish but things didn't go well so I reinstalled ubuntu mate 18.04 on the Pi. But some problems occurred.

```
$ catkin but it is not going to be installed
$ rosvesion -d → unknown
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Doctor Matson told us that the Pi wouldn’t be great to run ROS cause its computing power is not enough. So he gave us the Nvidia Jetson TK1 but we didn’t know the password that the former user has set, so we’re reinstalling from the beginning.

- Vision road detection

  The definition of the road is uncertain, and it is hard to find out which is the road outdoor, especially the off-road. At first, we have to define which is the road on the indoor, and outdoor. Second, we have to train the car to detect the road. First, we test the car in the indoor, and if the car drives well, we’ll try outdoor.

References

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