Self-driving robot with obstacle avoidance

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I. INTRODUCTION & MOTIVATION

The purpose of this project is to build a robot which can do self-driving task in an environment with obstacles, which is also the task in RobotX. I will try to give the robot a pair of latitude and longitude, and I will let the robot navigate to the goal point and also avoid the obstacles. And then I will test this system in marine Gazebo enviroment, and replace the wheel robot to WAM-V gazebo model.

II. SYSTEM ARCHITECTURE & EQUIPMENTS

I use the wood and some Aluminum stick to build the robot. My robot has IMU, GPS, Wheel odometry and LIDAR (Velodyne VLP-16) on it as its' sensors.

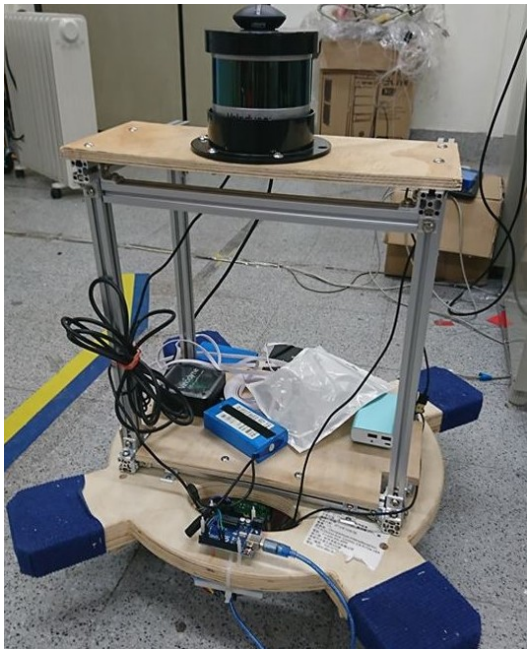

Fig. 1. Self-driving robot

III. SPECIFIC AIMS

- Localize robot with GPS, IMU, wheel odometry and LIDAR.
- Use point cloud to cluster and find the obstacle
- Plan a path to let the vehicle navigate without collision
- Build a simple global map to describe the obstacle position

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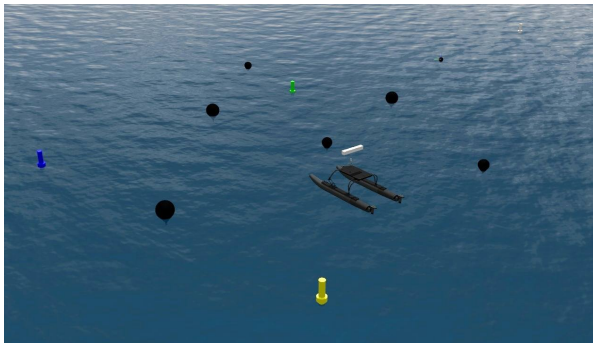

Fig. 2. Gazebo WAM-V obstacle avoidance

IV. APPROACH

A. Localization

I use IMU, GPS and wheel odometry to do EKF(Extended Kalman Filter). Also, I add LIDAR measurement to do SLAM (GMapping). And these two way can both get a robot odometry measurement. So I take these two odometry data do fusion again, and then I can get a very good robot localization and mapping.

B. Point cloud Processing

First, I make the noise filter, which can remove the outlier noise. And then I use plane filter to remove the floor, because the floor will affect our clustering result. Finally, I use K-means to do clustering, and then use a convex hull to present the obstacle by its' vertex. As a result, each obstacle can be present as a list of points.

C. Path Planning and Following

I choose a method refer from the paper [1] to do path planning, and use pure pursuit to follow the path. Then it can let the robot achieve goal point and also avoid obstacles.

D. Demo videos

- Pure pursuit algorithm visualization:
  `https://youtu.be/DdaZkm7_bjI`
- Self-driving at EE-building indoor:
  `https://youtu.be/ve4Mln4D1xo`
- Self-driving at EE-building outdoor:
  `https://youtu.be/E1anLPuXjxs`
- Self-driving WAM-V for RobotX task6:
  `https://youtu.be/DBuMrUvr7iY`

REFERENCES

[1] H.-Z. Zhuang, S.-X. Du, and T.-J. Wu, "Real-time path planning for mobile robots," in *2005 International Conference on Machine Learning and Cybernetics*, vol. 1, Aug 2005, pp. 526–531.