Individual Lab Report

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Team B – Auto Pirates
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1 Individual Progress

In this week, William has generated fake data in OpenCPN, published it to ROS topics and visualized the data in ROS topics. This means we have successfully interfaced between OpenCPN and ROS. I researched on the data format of radar we are using and how to preprocess the radar data. So once we finished logging the real Radar data in NREC, we can begin to preprocess and filter the data. Besides this, I also worked with Tushar and William to revise the CoDR.

1.1 Radar data format

From the paper that I read last week and the source code of the Radar plugin in OpenCPN, the radar data format can be summarized as follows:

1. The maximum range of the Radar can be set between 60m(according to the paper) and 36nmi(according to the data sheet of the Radar).
2. The Radar image consists of 2048 range scans(spokes).
3. Each spoke consists of 512 cells.
4. Each cell is indicated by a 8-bit value.
5. The value of each cell is determined by the sum of the energy .
6. The beam width of the Radar is about 5.2 degree, which means each cell is illuminated several times during a circle of scan.

1.2 Radar data preprocessing

I also did research in how radar data preprocessing works. The purpose for Radar data preprocessing is to convert the data we received into a binary data, where the occupied cell indicates the existence of an obstacle. To do this, three steps need to be done.

1. Ego motion Compensation

   The first step is to compensate boat's yaw rate. This will be done when we overlay the visualized radar data and the map. We should take the heading of the IMU output to correct the location of obstacles shown on the map.

2. Occupancy Likelihood Determination

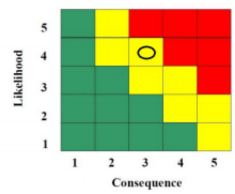
   Since the beam width is greater than the width of every spoke, one cell is illuminated more than one time, and the intensity is hard to calculate at this kind of situation. The strategy here is to assume one cell as occupied if the value is greater than zero, then the occupancy likelihood can be calculated using the equation below:

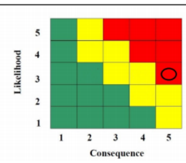
   $$P_r = \Sigma_{k=0}^{m} (nk)^T p^k (1-p)^{n-k}$$

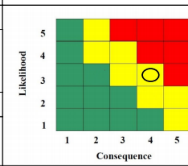
   where

   $$m = \Sigma_{-n/2}^{n/2} a_{i,j+l}$$

Figure 1: Risk Management

Risk Title	Risk Owner	Date Submitted	Date Updated
Boat Availability	Tushar & Tae-Hyung	10/28/2015	10.29/2015
Risk Type	Testing	**Risk Level**	
Description of Risk			
Field tests and developing time are limited with weather conditions, budget and boat driver availablility			
Consequences			
Delay in the schedule and insufficient data collected			
Mitigation Plan			
Action	**Due Date**	**Expected Outcome**	
Purchase a new radar	11/9/2015	Can do more perception testng	
Create a simulator	11/21/2015	Can do more path planning testing	
Appoint a field manager to plan logistics of each test	10/29/2015	Can test more efficiently	

Risk Title	Risk Owner	Data Submitted	Data Updated
Radar Performance	Shiyu	10/28/2015	10/29/2015
Risk Type	Technical	**Risk Level**	
Description of Risk			
Radar yields poor performance and is difficult to implement.			
Consequences			
Time will be limited to implement new sensors			
Mitigation Plan			
Action	**Due Date**	**Expected Outcome**	
Investigate other sensors as we do development	--	can switch to other sensors quickly once we failed in implementing Radar	
talk with researchers who have experience in Radar perception	11/9/2015	Researchers can give us insight in implementing Radar and perception algorithms	

Risk Title	Risk Owner	Data Submitted	Data Updated
Intergration	William & Bikram	10/28/2015	10/29/2015
Risk Type	Technical	**Risk Level**	
Description of Risk			
Each subsystem team will be working mostly independently. This may lead to integration problems.			
Consequences			
It will take long time to integrate perception and path planning subsytems			
Mitigation Plan			
Action	**Due Date**	**Expected Outcome**	
Code Review	--	Each team member will understand everyone else's code	
Create a detailed software architecture	11/3/2015	will help us understand subsystem interfaces	

i here represents the cell index and j represents in azimuth, $a_{i,j}$ represents the occupancy value of each cell. In other words, if one cell is occupied, $a_{i,j} = 1$; if one cell is not occupied, $a_{i,j} = 0$.

Finally, the cell is considered to be an obstacle is $Pr > 0.5$.

3. Connected Component Labelling

   After step 2, we will be able to get a binary image with the information of obstacles. As one obstacle may consist of several cells, we need connected component labelling(or blob discovery)to detect all the connected regions.

1.3 Revising CoDR

This week I also revised the risk management and fall validation experiments of perception part in our CoDR. In risk management part, I chose top 3 risk in our project and analyzed the risk level and the mitigation plan as figure 1 shows:

In the fall validation experiments for perception, I changed the scope of perception for fall semester based on the research we have already done.

The changes can be summarized as follows:

1. Combined log play part with perception and path planning, so test can be done more efficiently.
2. Clarified how we plan to show the performance of obstacle detection: by showing radar image and recorded video at the same time.
3. Clarified the obstacles we are detecting: at least the boats.

2 Challenges

The first challenge for this week is to understand the data type of Radar. Although the paper I am reading tells the data type of the radar they used, we still need to figure out the data type for our radar. I checked the code for the Radar plugin in OpenCPN and I was able to find the data type sent in the program as I described in individual progress. However, there is small difference between the radar used in the paper: Their data is 1024 cell one spoke with 4 bit data in every cell and our data is 512 cell one spoke with 8 bit data in every cell; the maximum range of their radar is 32nmi and the maximum range of our radar is 36nmi.

The second challenge for this week is to understand the preprocessing of Radar data described in the paper, and I will take next week's time to do more researches, especially in the area of connected component labelling.

3 Teamwork

After Tae-Hyung suggested us to use the SBPL library, we have much progress in path planning:

Tae-Hyung arranged a meeting with the software specialist in SBPL lab in CMU and he also worked in building the sample code of SBPL library. He also suggest the need of generating a bitmap for path planning.

Tushar worked with Tae-Hyung to use SBPL library for path planning tasks. And he also revised the CoDR together with me.

Bikram also worked on the SBPL library and was able to generate a path based on a example map using the library. He also developed the simulation environment in Gazebo.

William successfully interfaced between OpenCPN and ROS based on fake data. He also worked with me and Tushar to revise the CoDR.

4 Future Plan

For the perception part in our project, my plan is to go to NREC to test the performance of our radar. The performance should include the minimum range and size that the Radar will be able to test. The second thing is to learn the basic algorithm for connect component labelling like two-pass algorithm and sequential algorithm.

I also need to work with my teammates to finish the PCB assignment.