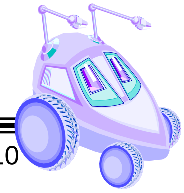


Final Project: Localization and Map Making

Lectures: 8-1 and 8-2

Reading: Ch. 11, *Introduction to AI Robotics*

(Demonstrations due in class on **Monday and Tuesday of Week 10**)

(Competition in Kahn room on **Thursday of Week 10**)

(Project Report and Code due in Angel drop box by midnight on **Friday of Week 10**)

Purpose: The purpose of the final project is to demonstrate the integration of some of the concepts learned this quarter by creating a localization and mapping algorithm for the Traxster II. The localization task involves using sensor feedback with a navigation routine to determine the location of a lost or kidnapped robot in the world and then move it to its home location. The mapping task involves the creation of a hybrid topological and metric map of the robot's world by using sensor feedback and an exploration algorithm.

Equipment: Base Robot
Various sensors and peripherals

Software: Microsoft Visual Studio.NET 2008 with C#
Serializer.NET library and firmware
Bluetooth transmitter

Part I - Localization

1. The user will provide the robot with an a priori map of the world as an 8 x 8 array with topological map encoding in a .txt file.
2. The localization algorithm should process this map to identify key features such as the distinctive locations or gateways (corners, hallways, dead-ends, t-junctions). For example, 12, 9, 6, and 3 indicate corners (C) in the world. Although it is a not a distinctive feature, a series of 10's or 5's or neighboring 1's and 4's or 8's and 2's indicate a hallway (H) in the world. The numbers (1) indicate a gateway where the robot can make a navigation decision. The distinctive features or gateways are the nodes in the world and the hallways

can be used with a local control strategy such as follow center or follow center to move between nodes. An example of coding a map is shown in Figure 1.

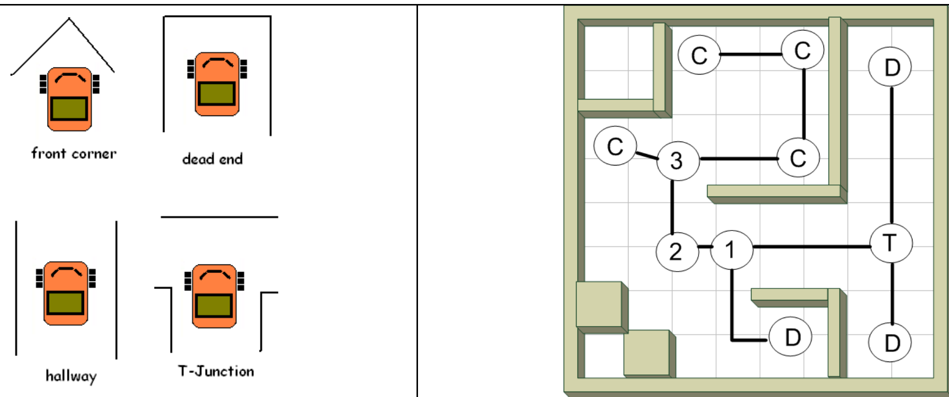


Figure 1: Feature Extraction (Map Coding)

3. Once the robot is placed in the world, the robot should then use some motion algorithm such as random wander, follow center, wall following to explore the world and identify gateways. It should keep track of the gateways passed and the order in which they were passed. Although there will be some odometry error, it would also aid the localization algorithm to keep track of odometry such as distance traveled and turns. Within three to four iterations of this process, the robot should be able to use a probabilistic method such as the Partially Observable Markov Decision Process (PMDP) to localize itself. Figure 2 provides an example of this localization process with the proposed robot locations after each step marked on the map.

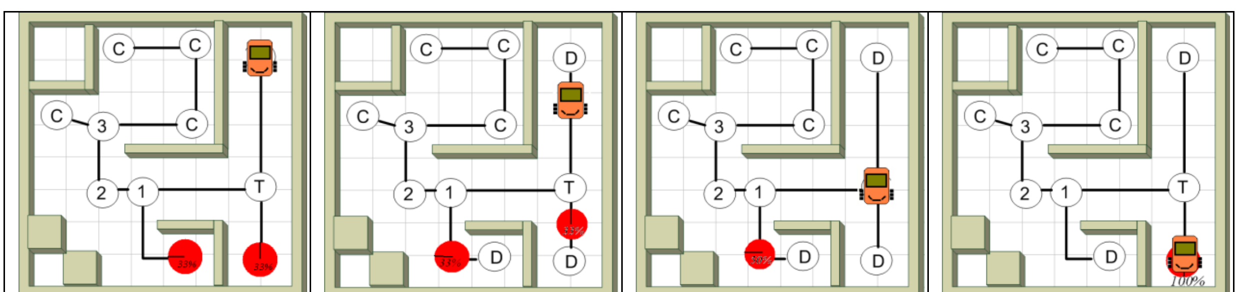


Figure 2: PMDP Localization

4. Lastly, after determining its location using registration, the robot should use wavefront propagation to plan a path from its current location to the goal location (or home). The robot's home position will be specified at run time.
5. During the demonstration, the robot will be placed in the world at an arbitrary location and move between nodes until it is able to determine its location in the world. The robot should then plan a path and move home.

Part II - Map Making

1. In this exercise, you will build a map of the 6' x 6' test arena by using a cover algorithm and sensor feedback. The robot should be able to use the created map to plan a path from a start position to a goal location. Try to reuse as much code as possible from Part I and prior labs once the map has been created to simplify the path planning and execution.
2. Note that mapping will be tricky because of odometry error, sensor error, and other sources of error. A completely accurate map would require localization to reduce the uncertainty of position. However this would require SLAM which is difficult to implement. Therefore, using only the dimension of the environment and the robot start position for the mapping try to create the best map possible.
3. You can use teleoperation, wander, cover, wall following or any other motion algorithms to move the robot through the environment and code the space where the IR or sonar hits objects with a value. One possible technique is to create a generalized Voronoi diagram to efficiently explore the environment.
4. To create the occupancy grid, you can use a Bayesian, Dempster-Shafer or Histogrammic in Motion Mapping (HIMM) techniques. Figure 3 provides an example of a Generalized Voronoi Graph (GV) with HIMM labeling.

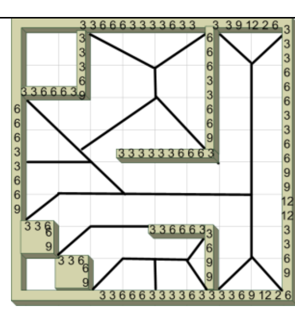
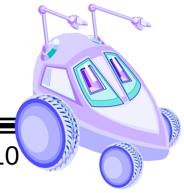


Figure 3: GVG with HIMM



5. During the demonstration, the robot will be placed in the world and begin to explore the environment and create the map. Your program should output the matrix array as a text file which represents the world map (occupancy grid or topological map is okay). You may also use the MapTools code provided on Angel to draw the created map on a grid but it will need to be modified to integrate sensor and odometry data. Lastly, you will be given a start position and goal location for your robot on the newly created map. The robot should then plan a path from the start position to the goal location and execute it. You will be graded on the ability to generate the map, the accuracy and detail in the map and how well the robot is able to use your world map to plan a path to a goal location while avoiding obstacles.

Evaluation

Because this project requires an integration of several concepts and is more difficult than the prior labs, there will be **2** demonstrations required and a graduated grading scale. Table 1 shows the point distribution for the final project.

Table 1: Project Grade Point Distribution

Task	Percent
Demo 1 – Localization	25
Demo 2 – Map Making	25
Code	25
Report	25
Competition – 3rd place	5 pt bonus
Competition – 2nd place	7 pt bonus
Competition – 1st place	10 pt bonus

Submission Requirements

You must demonstrate localization by **Monday of Week 10**.

You must demonstrate map making by **Tuesday of Week 10**.

Your team will use these algorithms during the final competition on **Thursday of Week 10**.

Details of the final competition will be provided later.

You must submit your properly commented code and final project report by midnight on **Friday of Week 10**. Recall that properly commented code has a header with the solution name, team members' names, description of the functionality and key functions, revision dates. In addition, all of the key variables and functions in the code are commented. Please use the following checklist to insure that your final project report meets the minimum guidelines.

Project Report Guidelines

1. The document should have default Word settings with respect to font and margins
2. All pages should be numbered
3. All headings must be numbered, left-justified, bolded, and capitalized at the beginning of the section.
4. All figures must have a number and caption underneath (i.e. GUI screenshots)
5. All tables must have a number and title above it (i.e. results error analysis)
6. The cover page should have title, partner names, course number and title, date
7. The report should order should be:

    Cover page
    Abstract
    Table of Contents
    I. Objective
    II. Theory
    III. Methods
    IV. Results
    V. Conclusions and Recommendations
    Appendix/Supplementary Materials
    References (if any)

8. The ***abstract*** should be a brief statement of the experiment purpose and relevant results
9. The ***objective*** should state the purpose of the project and associated tasks in your own words
10. The ***theory*** should state relevant theory that will be used to implement the robot tasks analyze the experimental results
11. The ***methods*** section should summarize the procedure used to test the robot algorithms and confirm that they meet the project objectives
12. The ***results*** section should summarize the results of the tests and provide error analysis if necessary

13. The ***conclusions and recommendations*** should address whether the purpose was achieved, possible sources of error, recommendations to improve the robot algorithm and answer any relevant questions related to the project.
14. Remember this is only a guide for the minimum requirements of your report. You are required to answer any questions or provide any details that you feel aid the reader in understanding the objective, theory, procedure, implementation and results of your project.