



**Final Project:**  
**Fire Search Bot**  
**Localization and Search**

Lectures: Week 1 - 8 Lectures

Reading: *Mobile Robotics for Multidisciplinary Study* Textbook

(Demonstrations due in class during **Week 9 and Week 10**)

(Seeding in HMU on **Tuesday of Week 10**)

(Competition in HMU on **Thursday of Week 10**)

(Project Report and Code due in Moodle drop box by midnight on **Sunday of Finals Week**)

\*\*\*\*\*

**Purpose:** The purpose of the final project is to demonstrate the integration of some of the concepts learned this quarter by creating localization and search algorithms for the CEENBoT. The localization task involves using sensor feedback with a navigation routine to determine the location of a lost or kidnapped robot in the world, location of a fire (heat) source and then rescue it by moving it to its home location.

**Equipment:** Base Robot, Range sensors, Photoresistors, Temperature Array

**Software:** AVR Studio 4 (32-bit) available at

<http://www.atmel.com/tools/AVRSTUDIO4.aspx>

WinAVR GCC toolchain (<http://winavr.sourceforge.net/>)

CEENBoT API static library available at

<http://www.digital-brain.info/downloads/capi324v221-v1.09.002R.zip>

\*\*\*\*\*

**LAB PROCEDURE**

\*\*\*\*\*

**Part I - Localization**

1. The user will provide the robot with an a priori map of the world as a text file. The map will be a 4 x 4 array with topological map or occupancy grid encoding.
2. The localization algorithm should process this map to identify key features such as the gateways or distinctive places [corners (C), hallways (H), dead-ends (D), t-junctions (T)]. Although it is not a gateway, 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, 2, 3) 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 wall to move between nodes. An example of coding a map is shown in Figure 2.

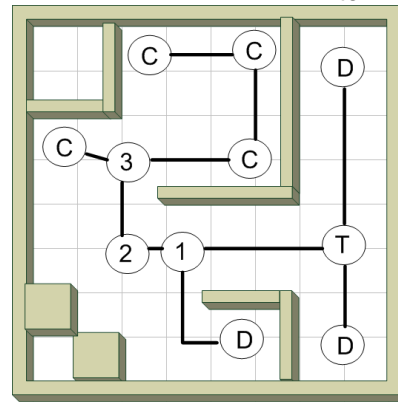
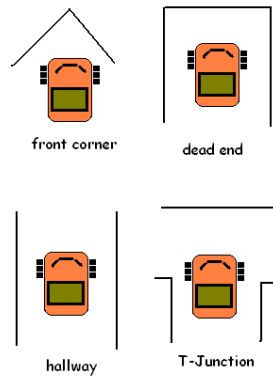


Figure 2: Feature Extraction (Map Coding)

- Once the robot is placed in the world, the robot should then use some motion algorithm such as random wander, follow center, or 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 3 provides an example of this localization process with the proposed robot locations after each step marked on the map.

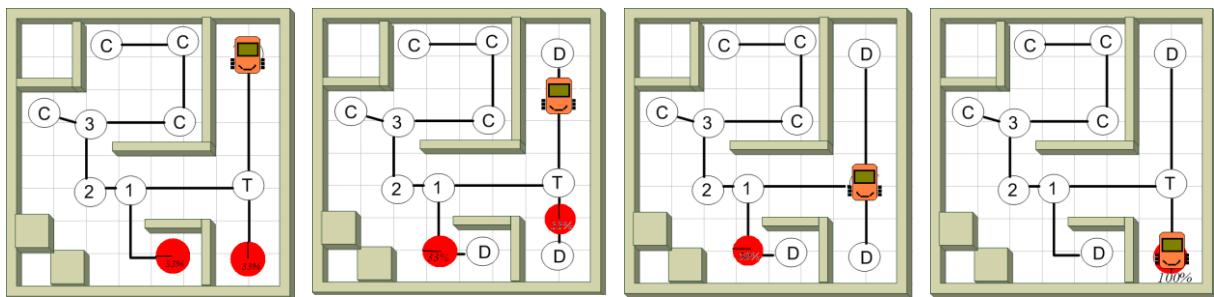


Figure 3: PMDP Localization

- 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 and goal location will be specified at run time. After localization, you can use your lab 7 code to plan a path for the robot.
- 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 -Search and Home**

1. The robot will be placed at a random start location in the world. This location will be denoted as the robot's 'home' position. The robot should then be able to use a movement algorithm to localize itself with respect to the world map. It should then make an audible or visible signal that it is localized.
2. There will also be a heat/light source placed randomly in the world. The robot's task is to use a search/cover algorithm to find the location of the heat/light source. The robot should make an audible or visible signal to denote that it has located the source such as a beep, light or LCD display.
3. The robot should then plan a path back to the home location and show the location of the source on the LCD. See Figure 4 for an example of the search and home task.

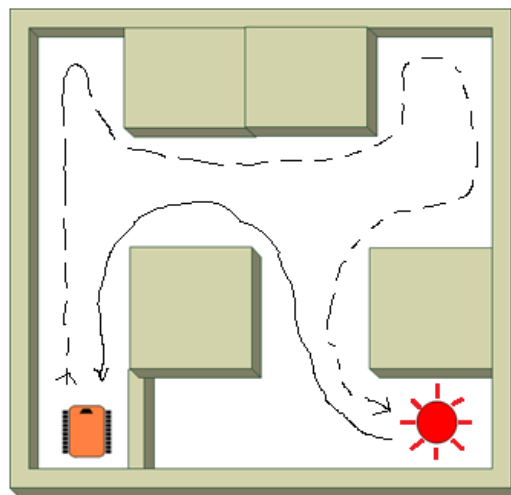


Figure 4: Fire Search Bot

**Evaluation**

Due to the complexity of this project and the fact that it requires an integration of several concepts, there will be **two** 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	Due by
Demo 1 – Localization and Path Planning	25	Thursday of Week 9
Demo 2 –Search and Home	25	Monday of Week 10
Code	25	Sunday of Finals Week
Report	25	Sunday of Finals Week
Competition – 3 <sup>rd</sup> place	5 pt bonus	
Competition – 2 <sup>nd</sup> place	7 pt bonus	
Competition – 1 <sup>st</sup> place	10 pt bonus	



**Submission Requirements**

You must demonstrate localization and path planning by **Thursday of Week 9**.

You must demonstrate search and home by **Monday of Week 10**.

Your team must complete **round one** of the final competition by **Tuesday of Week 10**.

Your team must compete during the final competition on **Thursday of Week 10**.

You must submit your properly commented code and final project report by midnight on **Sunday of Finals week**.

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, verification 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 achieve the purpose
11. The **methods** section should summarize the algorithms implemented to achieve the purpose and the procedures used to test the robot algorithms
12. The **results** section should summarize the results of the tests and verify that the robot was able to achieve the purpose and meet the project objectives
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.