Lab 8 Metric Path Planning (Topological Map)

Reading: *Introduction to AI Robotics (Ch. 10), Lectures 6-2, 7-1*

(Demonstration due in class on *Thursday*)

(Code and Memo due in Angel drop box by midnight on *Thursday*)

Purpose: The purpose of this lab is to implement metric path planning on by using a wavefront or grassfire expansion on a topological map to move the mobile robot from a start point to a goal point.

Equipment: Base Robot
IR/Sonar Sensors
Servo Panner

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

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LAB PROCEDURE

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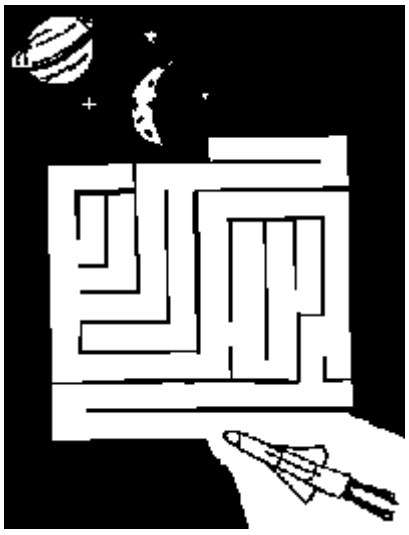
Topological Map Path Planning and Execution

1. In this exercise, you will use an a priori topological map to plan a path from the robot start location to a goal position using a wavefront algorithm. Instead of representing the world map as an occupancy grid as in last week's lab, it will be based upon the topology of the space. The salient features of the space are walls, hallways, corners and junctions. Each square will be represented by an integer between 0 and 15, dependent upon where walls are present around the square. The north (0001), east (0010), south (0100) and west (1000) walls represent one bit of that integer (see Table 1).

Table 1: Topological map coding

Integer	Binary	Hexadecimal	Direction	Wall Location
0	0000	0		
1	0001	1	North	
2	0010	2	East	
3	0011	3		
4	0100	4	South	
5	0101	5		
6	0110	6		
7	0111	7		
8	1000	8	West	
9	1001	9		
10	1010	a		
11	1011	b		
12	1100	c		
13	1101	d		
14	1110	e		
15	1111	f		

Using the coding in Table 1, the maze shown in Figure 1 is represented by an 11 x 10 matrix of integers.



15	15	15	15	15	13	5	5	5	3
9	5	7	9	1	5	5	5	5	6
10	11	11	10	10	9	5	5	5	3
10	10	10	10	10	10	11	11	11	10
8	6	10	10	10	10	10	10	10	10
8	5	6	10	10	10	10	10	10	10
8	5	5	6	10	10	10	10	6	10
10	13	5	5	6	8	2	10	9	2
12	5	5	5	5	6	12	6	10	14
9	5	5	5	5	5	5	5	4	7
12	5	5	5	5	15	15	15	15	15

Figure 1: Maze Topological Map

2. To use the topological map to plan a path from a robot start location to a goal point it is possible to use the wavefront algorithm again. However, instead of the robot moving to cells on the occupancy grid, the robot will use behaviors and rules such as move forward, turn left, follow wall, follow hallway, avoid obstacle, etc. The navigation involves taking the list of actions and executing them.

3. During the demonstration, you will be given the map as an 8 x 8 array of integers or hexadecimal numbers in a .txt file that represents the world's salient features. You will be given the robot's start position at the beginning of the demonstration. Your program should open the .txt file, read the world map as an array, and use an algorithm to plan the path to move the robot from the start position to the goal. You should then place your robot at the start position and press start and it should move to the goal point. You will be graded on how well your algorithm works; the efficiency of the path chosen by the robot, the ability of the robot to reach the goal point while also avoiding obstacles. *(Note that the robot's center of rotation is between its wheels not the center of the chassis so you should offset the robot in the starting cell so that the robot's center of rotation is at the center of the cell. Another technique to prevent the robot from hitting walls and obstacles is to select the path that maximizes the distance between walls and obstacles or the center line.)*

Demonstration:

In the demonstration of the program for lab 8 the robot will navigate from the start point to the goal point using wavefront expansion on the topological map of the salient features. The list of robot commands and generated wavefront should be shown on the GUI to make it evident the state that the robot is in.

Program:

The program should be properly commented and modular with each new behavior representing a new function call. The design of the architecture should be evident from the

program layout. You should use the GUI, keypad, LCD and speech module as needed to illustrate robot state, input and output data.

Memo:

The following list provides the basic guidelines for writing a technical memorandum.

- ✓ Format
  - Begins with Date, To , From, Subject
  - Font no larger than 12 point font
  - Spacing no larger than double space
  - Written as a paragraph not bulleted list
  - No longer than three pages of text
- ✓ Writing
  - Memo is organized in a logical order
  - Writing is direct, concise and to the point
  - Written in first person from lab partners
  - Correct grammar, no spelling errors
- ✓ Content
  - Starts with a statement of purpose
  - Discusses the strategy or pseudocode for implementing the robot paths (may include a flow chart)
  - Discusses the tests and methods performed
  - States the results including error analysis
  - Shows data tables with error analysis and required plots or graphs
  - Answers all questions posed in the lab procedure
  - Clear statement of conclusions

Questions to Answer in the Memo:

1. What was the strategy for implementing the wavefront algorithm?
2. Were there any points any the navigation when the robot got stuck? If so, how did you extract the robot from that situation?
3. How long did it take for the robot to move from the start position to the goal?
4. What type of algorithm did you use to selection the most optimal or efficient path?
5. What were the key differences between using the metric and topological map? Was one representation easier to work with than the other?

6. How did you represent the robot's start and goal position at run time?
7. Do you have any recommendations for improving that robot's navigation or wavefront algorithm?

Grading Rubric:

The lab is worth a total of 30 points and is graded by the following rubric.

Points	Demonstration	Code	Memo
10	Excellent work, the robot performs exactly as required	Properly commented, easy to follow with modular components	Follows all guidelines and answers all questions posed
7.5	Performs most of the functionality with minor failures	Partial comments and/or not modular with objects	Does not answer some questions and/or has spelling, grammatical, content errors
5	Performs some of the functionality but with major failures or parts missing	No comments, not modular, not easy to follow	Multiple grammatical, format, content, spelling errors, questions not answered
0	Meets none of the design specifications or not submitted	Not submitted	Not submitted

Submission Requirements:

You must submit the lab memo and code by midnight on *Thursday*. You must also submit a memo for Lab 6 by midnight on *Thursday*.