Lab 5 Homing – Hybrid Control

Reading: *Introduction to AI Robotics (Ch. 7), Lec. 5-2*

(Demonstration due in class on *Thursday*)

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

Purpose: The purpose of this lab is to use a type of locomotion called ***homing*** or ***docking*** with hybrid control to move the Traxster toward a heat beacon. There will be a heat beacon placed in the environment which the robot can easily sense. The goal will be for the robot to move toward the beacon and stop just before hitting it. There will be no fixed path to the beacon, the robot should follow the walls and avoid obstacles until the beacon is sensed, it should then leave the wall, and use the move to goal behavior to dock on the source. Lastly, the robot should then attempt to return to the wall by turning 180 degrees follow as near as possible to the spot where it left.

Equipment: Base Robot
Thermopile Array
Servo Panner
Heat source

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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Part 1 – Testing the temperature array

1. The TPA81 can detect a candle flame at a range of 2 meters (6 feet) and is unaffected by ambient light. It can also be used to control a servo although you will control panning of the array on the servo through your code. Recall that the first data point on the array is the ambient room temperature. The field of view is 41° by 6° for the eight sensors with each one having a field of view of 5.12° by 6°. A human at 2 meters will show up as approximately 84°F with an ambient temperature of 68°F.
2. Calibrate your thermopile array by measuring the detected temperature versus distance and angle from the source (person, laptop, heater, etc). You should include this data table with objects, distances and temperatures in you lab memo. Use this calibration in order to develop the reactive layer of the control architecture.
3. You should include a data table in your lab memo that indicates your results.

Part 2 – Move To Goal (Homing)

1. The hybrid control architecture that you will implement to home the robot includes a reactive layer (obstacle avoidance, wall following, move to goal, path update), middle layer (arbitrator), and deliberative layer (current state, path plan back to wall). This architecture is shown in Figure 1. Your code should be written in a modular fashion with functions such that it is evident where the planning, sensing and acting take place.

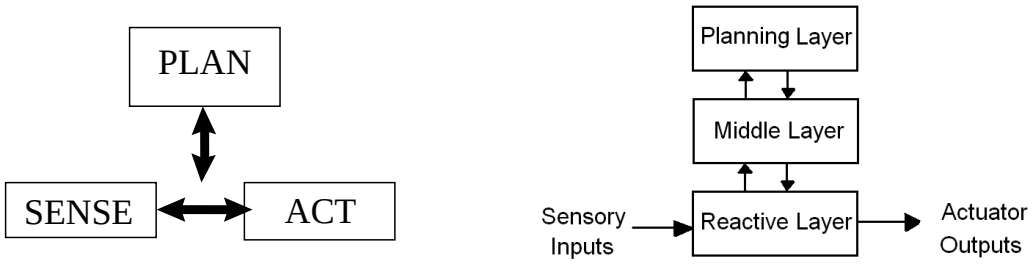

Figure 1: Homing Hybrid Control Architecture

2. The partial world map (representation) includes direction to the beacon and back to the wall with respect to the robot's current pose. This representation will be input into the deliberative layer for path planning. Updates to the path will be based upon feedback from the distance, heading and thermopile sensors. The middle layer will be used to

make decisions about whether path updates are handled in the deliberative or reactive layer. The reactive layer will handle obstacle avoidance, wall following and move to goal behaviors. The robot should turn around and follow the path to drive back to the wall.

3. Based upon the above model, write code to home the Traxster robot to the heat source (see Figure 2). The robot should come within one foot of the beacon without touching it.

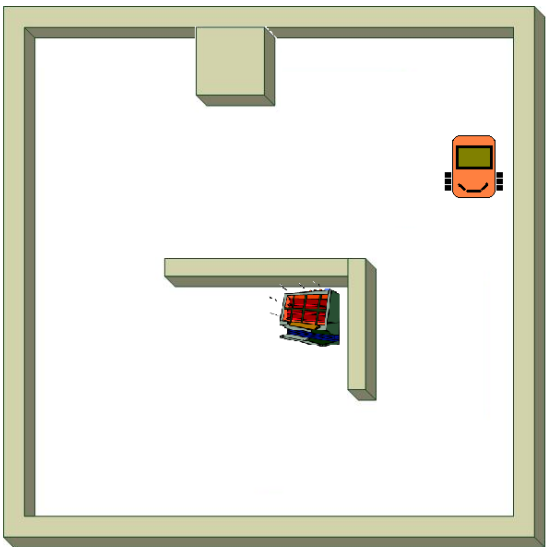

Figure 2: Robot homing

4. Test your final control algorithm for several different robot start points or beacon locations and summarize the results in your lab memo.

Part 3 – Dock the Robot and Return to the Wall

1. Improve the homing routine implemented in part 2 by docking the robot and returning to the wall to continue to follow where it left off. The robot should turn around and follow the path to drive back to the wall.

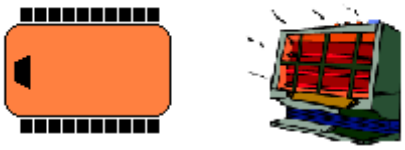

Figure 3: Robot Docking

Demonstration:

The demonstration of the program for lab 5 will include three parts. In the first part, the robot will be placed in the environment, wander until it finds a wall and then follow the wall until the heat beacon is detected. The robot should then move to goal and stop within one foot of the heat beacon. In the second part, the robot should turn and dock on the heat. Lastly, the robot should return to the wall as close as possible to where it left off and continue to follow the wall.

Program:

The program should be properly commented and modular with each new behavior representing a new function call. The design of the subsumption 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 does the hybrid control architecture for your design look like? What was on the planning layer? Middle layer? Reactive layer?
2. What were the results of the testing of the servo and thermopile array?
3. What was your general strategy for planning the path back to the wall from the heat source?
4. How reliable was the thermopile array at detecting different objects such as a human or the space heater.
5. Compare and contrast sensor data from a person, heater and your laptop or other objects.
6. How significant was the difference in temperature readings between the individual sensors on the array? How did you use this difference to extract directional information to move the robot toward the beacon?
7. How significant was the difference in temperature readings based upon distance from the source? How did you use this difference to extract distance information to move the robot toward the beacon?
8. How did the architecture respond to differences in robot start position or beacon location?
9. How did the robot's hybrid controller respond to dynamic changes in the environment (i.e. other robots and people) and compare this to purely deliberative control.
10. Were there any challenges in implementing the homing routine?
11. What could you do to improve the robot homing?
12. How did docking the robot modify the control architecture or algorithm?
13. How could you use the thermopile array for person tracking?

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 5 by midnight on **Sunday**.