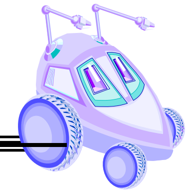

Lab 5 Homing – Hybrid Control

(Demonstration due in class on Thursday, 4/30/09)

(Code and Memo due in Angel drop box by midnight on Friday, 5/01/09)

Reference: http://roboticsprimer.sourceforge.net/workbook/Locomotion:Exercise3-Homing

http://roboticsprimer.sourceforge.net/workbook/Hybrid_Control

Purpose: The purpose of this lab is to use a type of locomotion called *homing* with hybrid control to move the Traxster toward a beacon. There will be a heat beacon placed in the environment which the robot can easily sense. The goal of the robot is to move toward the beacon and stop just before hitting it. There will be no fixed path the robot should follow but it will use a priori information to plan a path to the beacon. Once the robot is in the vicinity of the beacon, it will use a thermopile array to detect the beacon. In prior labs, you used reactive control to implement obstacle avoidance and that will be the reactive layer of the hybrid control architecture. The deliberative layer will plan the path to the beacon given the a priori directional information. This plan may be modified based upon odometry, compass, sonar, infrared and thermopile feedback as the robot moves. This is the most basic deliberative control and the map will not be resident on the robot but available off line for user input to the robot control architecture. Next week you will implement the same homing routine using behavior-based control and examine the differences.

Equipment:
- Base Robot
- Thermopile Array
- Compass
- Servo Panner
- Space Heater

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

Part 1 –Checking the new peripherals

1. Over the spring break, there were several peripherals mounted to your robot. Including a servo panner, sonar, thermopile array and compass. Go to the Lab 5 folder in Angel and download all of the provided files.
2. Run the *Compass_App.exe* and confirm that the compass is working. This code may have to be calibrated in order to reflect your closest estimate to true North
3. Run the *Temp_App.exe* and confirm that the thermopile array mounted to the front of the servo panner is working properly. There are 9 sensors on the array and sensor 0 represents the ambient temperature. You can test the functionality of the 8 horizontal sensors with detection of your body heat, the cooling fan on your laptop or the space heater.
4. You will use the *IRSonar_App.exe* to confirm the functionality of the IR, Sonar, Servo GUI. The test button can be used if you would like to see how the sonar, IR and servo will eventually work together. Note that the sonar and IR data has not been scaled to be consistent with each other or to scale with the robot. One of your tasks will be to determine scale factors to make it display logically on the GUI.

Part 2 – Homing the Robot - Hybrid control

1. The hybrid control architecture that you will implement to home the robot includes a reactive layer (obstacle avoidance, path update), middle layer (arbitrator), and deliberative layer (plan path to the beacon). 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.

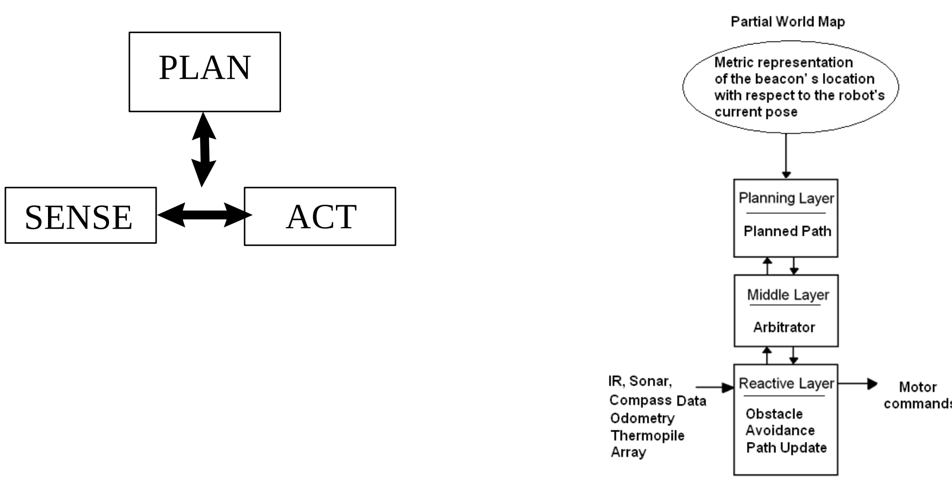

Figure 1: Homing Hybrid Control Architecture

2. The 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.
3. Calibrate your thermopile array by measuring the detected temperature versus distance 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.
4. The partial world map (representation) includes metric distance and direction to the beacon 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.
5. 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.

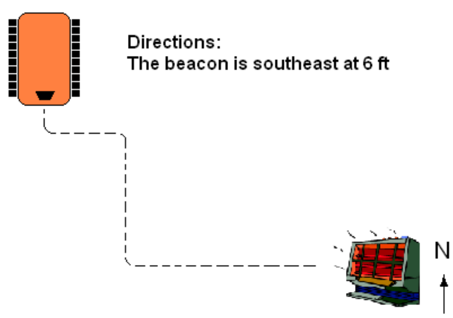

Figure 2: Robot homing

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

Part 2 – Docking the robot

Improve the homing routine implemented in part 2 by specifying the robot orientation at the beacon. Assume that the heat source is a docking station that the robot must back into. The robot should still come within one foot of the beacon without touching it (see Figure 3).

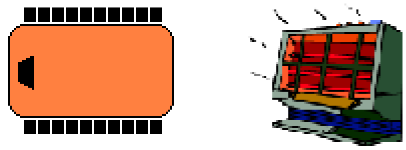

Figure 3: Robot Docking

<u>Questions to Answer</u>

1. What were the results of the testing of the servo, compass and thermopile array?
2. What was your general strategy for implementing the 2 versions of the homing routine?
3. How reliable was the thermopile array at detecting different objects such as a human or the space heater.
4. Compare and contrast sensor data from a person, heater and your laptop or other objects.
5. 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?
6. 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?
7. How reliable was the compass for direction sensing in moving 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. How could you modify the partial world map to improve the homing routine?
11. Were there any challenges in implementing the homing routine?
12. What could you do to improve the robot homing?
13. How did docking the robot modify the control architecture or algorithm?
14. How could you use the thermopile array for person tracking?

Submission Requirements:

You must demonstrate your homing routine by **Thursday, 4/30/09**. You must also submit properly commented code and a memo for Lab 5 by midnight on Friday, **5/01/09**. Please use the following checklist to insure that your memo meets the basic guidelines.

<u>Memo Guidelines</u>

- ✓ Format
  - o Begins with Date, To , From, Subject
  - o Font no larger than 12 point font
  - o Spacing no larger than double space
  - o Includes handwritten initials of both partners at the top of the memo next to the names
  - o Written as a paragraph not bulleted list
  - o No longer than two pages of text
- ✓ Writing
  - o Memo is organized in a logical order
  - o Writing is direct, concise and to the point
  - o Written in first person from lab partners
  - o Correct grammar, no spelling errors
- ✓ Content
  - o Starts with a statement of purpose
  - o Discusses the strategy or pseudocode for implementing the robot paths
  - o Discusses the tests and methods performed
  - o States the results including error analysis
  - o Answers all questions posed in the lab procedure
  - o Clear statement of conclusions