Lab 05

Braitenberg Vehicles

Reading: *Ch. 3 of text*

Read this entire lab procedure before coming to lab.

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Purpose: The purpose of this lab is to use two photo resistors connected to the front of the Arduino Robot to implement light sensing behaviors. The light sensor will then be used to implement a reactive controller related to Braitenberg's vehicles 2 and 3. There will be a light source placed in the environment which the robot can easily sense.

Objectives: At the conclusion of this lab, the student should be able to:

- Experiment with a photo-resistor sensors to determine a relationship between light conditions and change in resistance and voltage output
- Implement Valentino Braitenberg's *Vehicles* to see the impact of simple reactive controllers and the characteristics exhibited by the robot under simple motor-sensory couplings
- Use the temperature sensor to sense a heat beacon in the robot's environment
- Implement a hybrid controller on a mobile robot
- Integrate homing and docking into the behavior-based controller designed in prior labs

Equipment: Arduino Robot

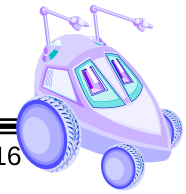
2 photoresistors

flash light

obstacles

Theory:

A photoresistor is a semiconductor device whose resistance is a function of light intensity. Because the resistance of the photo-resistor varies with light intensity, the current that flows through it also varies with light intensity. However, we want to monitor a voltage, not a current, since the ADC (Analog-to-Digital Converter) on the micro-controller takes voltage measurements. We will be able to monitor a voltage from the photo-resistor by creating a simple voltage divider circuit. The TinkerKit sensor has already taken care of the voltage divider circuit and just has to be attached to an analog pin on the robot.



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LAB PROCEDURE

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Part 1 – Photoresistor test

1. Mount the 2 photoresistors to analog pins on the front of the Arduino Robot. You may need to use masking tape in order to anchor them to the desired location.

2. Next, you should write a program to read the analog value of the photoresistors to calibrate for dark and light values. You will use these values to account for ambient temperature and help you implement the reactive controllers. Complete the following two tables for both sensors. You should include these tables in your lab memo submission.

Table 1: Environment Data

Conditions	Left Photoresistor (V)	Right Photoresistor (V)
Ambient light on the table		
Ambient light under the table		
Sensor covered		
In front of a flashlight		

Table 2: Distance and Angle of Incidence Data

Environment	Distance (inches)	Angle of Incidence -45°	Angle of Incidence 0°	Angle of Incidence 45°	Left Photoresistor (V)	Right Photoresistor (V)
On the table	3					
On the table	3					
On the table	3					
On the table	6					
On the table	6					
On the table	6					
On the table	9					
On the table	9					
On the table	9					
Under the table	3					
Under the table	3					
Under the table	3					
Under the table	6					
Under the table	6					
Under the table	6					
Under the table	9					
Under the table	9					
Under the table	9					

Part 2 - Reactive Control

1. The first program you will write is a reactive controller inspired by Braitenberg's vehicle experiments. In this step, you will create a vehicle that is wired with excitatory connections where each sensor is connected to the motor on the same side. The program controls the left and right wheels based upon the light intensity seen by the left and right photoresistors (see Figure 5a).

2. How does the robot behave when (a) the light source is directly in front of the robot, (b) the light source is to one side of the robot? Is there anything about the robot's behavior that surprises you?

3. Next, repeat parts 1 and 2 except that each sensor is connected in an inhibitory manner. This means the motor slows down as it gets closer to the light (See Figure 5b). The robot should start off driving forward at a moderate speed so that it is obvious when it slows down based upon light sensing.

4. Next, repeat parts 1 and 2 except cross the connections between the motors and the sensors so that the left light sensor controls the right motor's speed and vice versa in an inhibitory manner (See Figure 5c). Once again the robot should start off moving forward at a moderate speed so that it is obvious when it slows down.

5. Finally, repeat parts 1 and 2 with the connections still crossed between the motors and the sensors so that the left light sensor controls the right motor's speed and vice versa in and excitatory manner (see Figure 5d).

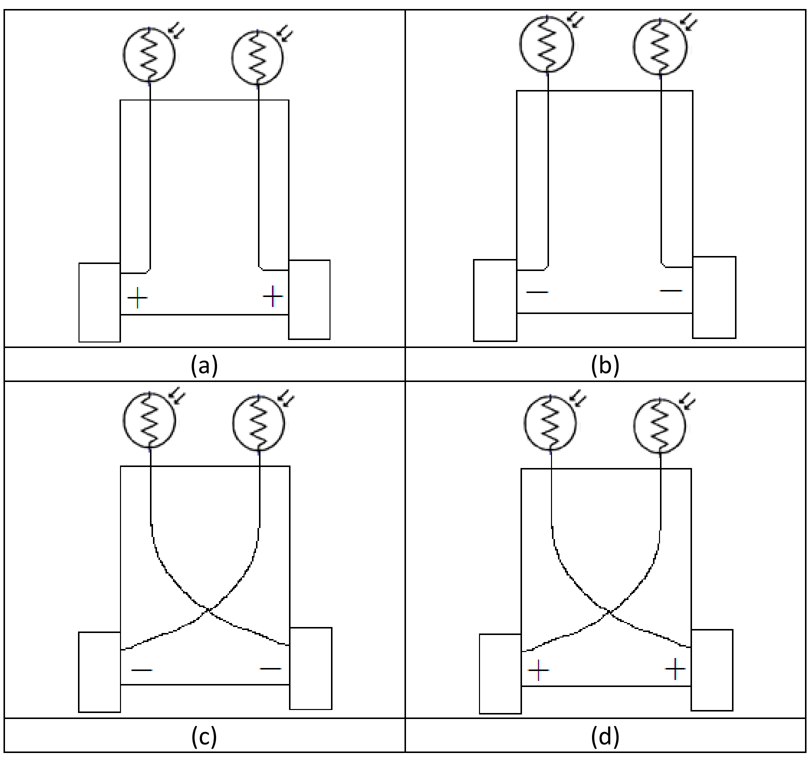

Figure 5: Valentino Braitenberg Vehicles

6. Braitenberg called these four light sensing behaviors, fear, aggression, love and explorer. These are the emergent behaviors that you did not explicitly program. Can you identify which of the four behaviors (fear, aggression, love, explorer) is exhibited for each of the prior motor/sensor connections?

7. How did you decide on the position of the photoresistors? Were there certain lighting conditions that were more difficult or easier for the robot to sense?

Part 3 - Obstacle Avoidance (layer 0)

1. After testing each of the sensorimotor connections individually and confirming that they work correctly, you should make this Layer 1 of the subsumption architecture.

2. Similar to the prior 2 labs, Layer 0 of the architecture should be obstacle avoidance. The robot should move with respect to the sensorimotor connections with respect to the light source while also avoiding obstacles. If the robot does not detect a light source or an obstacle then it should remain still (see Figure 6).

3. As an alternative to part 2, you can program the robot to or attempt to navigate around the obstacle to continue responding to the light. The obstacle avoidance behavior could be based upon potential fields (feel force) or the Bug1, Bug2 or Tangent Bug algorithms.

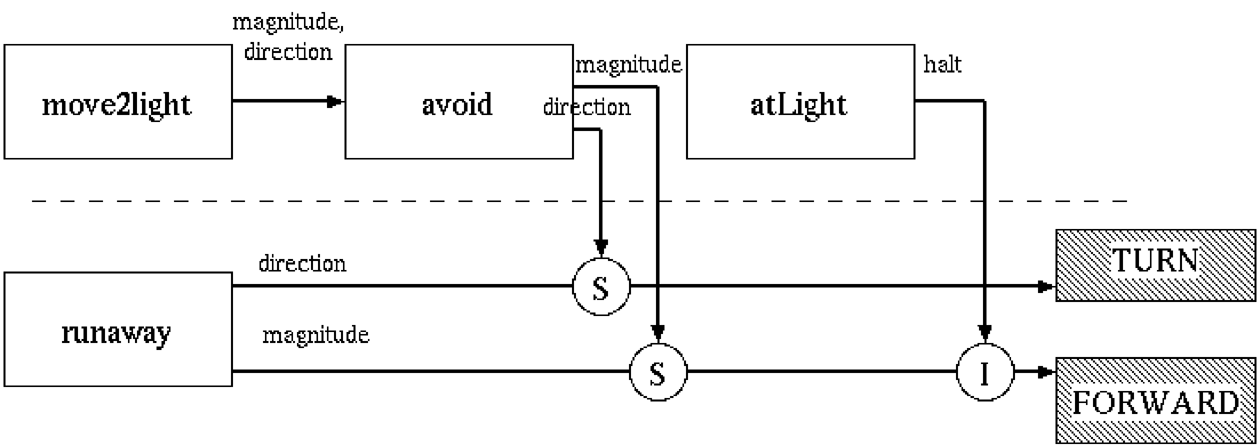

Figure 6: Sample Photophilic Architecture

Demonstration:

This week's demonstration will involving exhibiting each of the four vehicles described in part 2 of the lab procedure. It would be advisable to write all of the reactive controllers in one program that is selectable by pressing a push button on the robot to quickly transition from one to the other. You should also have a button that inhibits or enables the obstacle avoidance behavior.

Questions to Answer in the Memo:

1. How reliable was the photoresistor at detecting the light in different environments, various distances and angles of incidence (head on, slightly left, slight right).
2. How significant was the difference in photoresistor voltages for the left and right sides. How did you use this difference to extract directional information to move the robot toward the beacon?
3. How did you integrate the light sensors into the obstacle avoidance behavior?

Memo Guidelines:

Please use the following checklist to insure that your memo meets the basic guidelines.

- ✓ Format
  - o Begins with Date, To , From, Subject
  - o Font no larger than 12 point font
  - o Spacing no larger than double space
  - o Written as a combination of sentences or paragraphs and only bulleted list, if necessary
  - o No longer than three 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 remote control (includes pseudocode, flow chart, state diagram, or control architecture in the appendix)
  - o Discusses the tests and methods performed
  - o States the results and or data tables including error analysis, if required
  - o Shows any required plots or graphs, if required
  - o Answers all questions posed in the lab procedure
  - o Clear statement of conclusions

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 with a header and function comments, 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 your properly commented Sketch code & memo to the Moodle DropBox by midnight on Sunday. Check the course calendar for the lab demonstration due date.