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SUBJECT: ECE425: Lab 4: Hybrid Control- Light Reaction

The purpose of "Lab 4: Hybrid Control- Light Reaction" is to connect and read from two photoresistor sensors and implement light reactive behaviours for the robot. The light sensing behaviour that will be utilized will be similar to Braitenberg's "aggression" behaviour in that it the robot will follow the light. This light following behaviour will then be integrated with the already created behaviours: random wander and obstacle avoidance.

After having the ability to follow/move toward the light, a homing behaviour will be implemented. With homing, the robot will be able to reach the light source and then return to the path that it was traveling prior to homing.

Strategy:
This lab requires the implementation of new sensors, calibration is required. Two photoresistor sensors were attached at the front of the robot so that it may read and react to light. In order to create an accurate light representation, calibration tests are necessary. The robot was placed in different locations (on top and under tables) with a light at a specific distance and orientation away from it. Each of these different set ups resulted in different average readings, which can be seen in the appendix.

Once the photoresistors are calibrated and their associated readings are understood, light reactive behaviours can be implemented. The goal is to continue to use random wander and obstacle avoidance, as it has been used in previous labs, then adding the light reactive behaviour. As seen within the subsumption architecture within the appendix, the light sensing reactions will suppress the wander behaviour and be suppressed by the obstacle avoidance behaviour.

Memo Questions and Discussion:
After the calibrations, the reliability of Arbib detecting different environments was pretty high. Even when the light hit the photoresistors slightly left or right, the average difference from the head on voltage was only about 0.2V. So when the light source is six inches away from and directly in front of the photoresistors, the analog value that robot reads is only about 0.2V more than when the light is the same distance away, but angled to the right or left. Also, on average, the difference between the left and right photoresistors at the same distances was below 0.2V, so the difference between the two was not very significant. However, we used this difference to extract directional information to move the robot toward the beacon by adding a correctional value on to the right side.

This lab required an integration of the light sensing behaviours with the obstacle avoidance behaviours. This integration was established by using suppression within the code. Essentially, the robot would continue to move toward the light unless an object was detected. Then the robot would move around that object and return toward the light. While implementing the photoresistor, we focused on its ability to sense light, so object/wall sensing continued to be implemented by IR sensors. The IR sensors continued to be accurate at detecting different objects, as long as the objects did not appear in the wheeled corners of Arbib- there are no sensors there. There was also the chance for dynamic changes within the environment like other robots or people, when this occurred, Arbib treated them as obstacles/walls and attempted to move around them, once completed he was able to return to his previous state and move on. This reaction differs from the purely reactive control because within the purely reactive control, Arbib did not define separate states.

The photoresistors were fairly accurate, as long as the room was dark. When too much light was in the room, the robot frequently followed the wrong lights or did not readily detect the light beacon. Using the calibration and reactive control data, seen in the appendix, we were able to define appropriate ranges to get Arbib to the light source. We determined that the light could appropriately be sensed, within a dark room, at about 25 inches from the robot- this distance gave us a range of about 2.20-2.68 V for the robot to begin sensing light. The robot was then determined to be close enough to the source or to have “homed” within 6 inches or by having a range of about 3.66-4.15 V.

At the behaviour’s most basic function, it is the integration of Braitenberg’s aggression behaviour with the integration of wall following and random wander behaviours. When implementing homing, there were multiple challenges that needed to be overcome. One of the biggest problems we faced was making sure that the robot followed the light source, rather than a reflected copy of the light on a wall. Another problem that we faced here was ensuring that the robot actually made it to be consistent and centralized location for homing. To improve homing and ultimately eliminate the challenges that were faced, some more calibrations and corrections could be made to attempt to differentiate between the raw light and it's reflection.

After homing, docking was implemented. Homing brings the robot to the location and docking turns the robot around as if it were to back into the homing location. This behaviour would be useful for things like returning robots to charging ports. Adding this docking behaviour doesn't really change the control architecture though because docking simply happens immediately after homing. The general strategy implemented for planning the path back to the wall from the beacon was to save the (x,y) location and angle when the robot first sees the light, go to the light then return to the last location. The hope here was that this method would make implementing mapping and localization easier for the final project.

The hybrid control architecture for the design includes three main layers: planning, middle, and reactive. Within the planning layer Arbib defines/recognizes the current state that he is in and plans a path back to the wall. The reactive layer handles obstacle avoidance, wall following and moving to the goal. The middle layer acts as an arbitrator where Arbib decides whether to update the path using reactive or deliberative layers. With the implementation of this architecture, Arbib is able to accurately navigate around walls and to the homing beacon regardless of the start position or the location of the beacon.

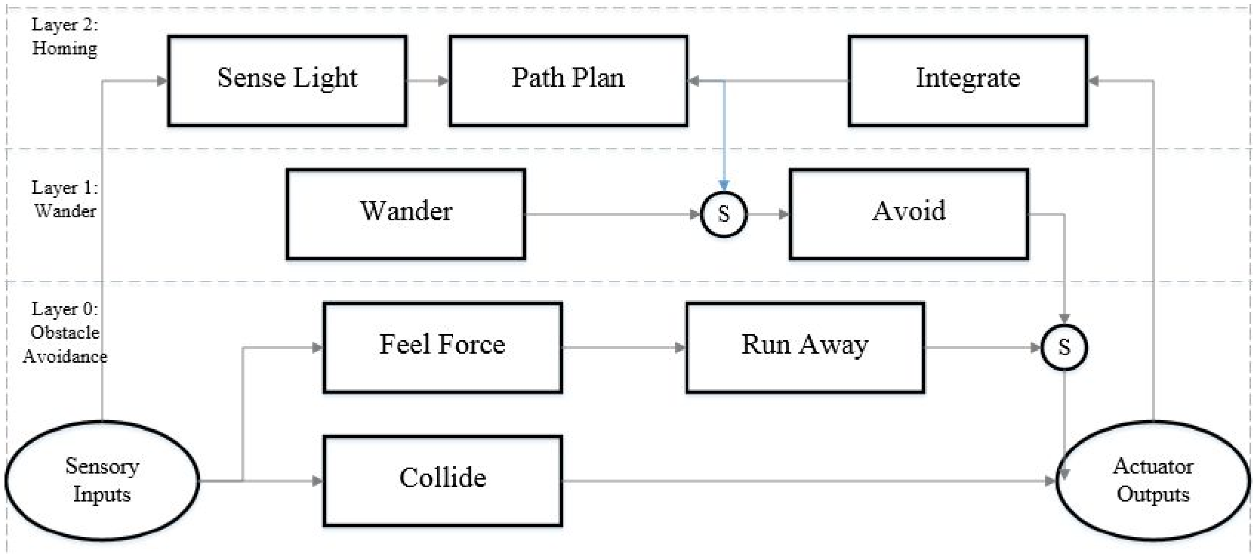
Conclusion:
In conclusion, the hybrid architecture to implement the previous functions (random wander, go-to-goal and obstacle avoidance/wall following) with the light sensing behaviours for homing and docking, was rather successful. Arbib was able to navigate from a random wander to following a wall and if the light/beacon was seen, Arbib was able to home to it, dock and return to the wall where he had left.

Also, all four of the Braitenberg vehicle behaviors were established and tested, although only the aggressive behaviour was used within the final code for homing and docking. The photoresistors were both tested and calibrated using various readings at multiple distances and orientations, this allowed us to accurately understand and represent how close Arbib was to a light, giving us the ability to home and dock efficiently.

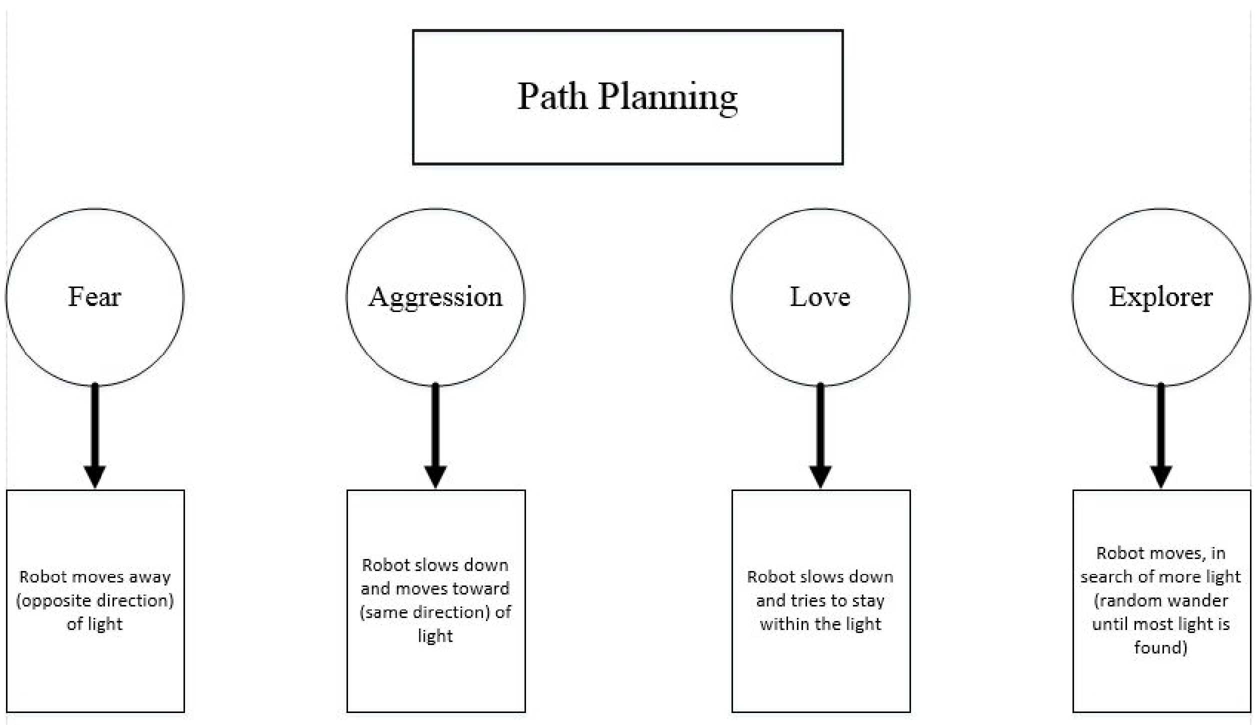
Within the final part of the lab, docking, an initial attempt at localization was established. Essentially, Arbib would save the (x,y) location and angle from the moment the light was sensed and after homing to the light, would use the go-to-goal function to return to that location and angle. The goal-to-goal function would use the vector sum of a vector towards the goal (seeing it as an attractor) and vectors opposite any detected obstacles, and then travel along that vector sum. This worked for the lab, but the accuracy of our odometric localization will need to be improved for the final project.

Appendix:

<u>Subsumption Architecture:</u>



<u>Define Path Planning options:</u>



Calibration:

Conditions	Left Photoresistor	Right Photoresistor
Average Ambient light on the table	851.538	829.484
Average Ambient light under the table	276.696	244.901
Average Sensor covered	3.708	3.809
Average from a flashlight or cell phone light	1014.603	1004.409

Reactive Control:

		Left Photoresistor			Right Photoresistor		
Environment	**Distance**	**-45°**	**0°**	**45°**	**-45°**	**0°**	**45°**
On table	6	953.378	955.918	915.235	895.968	914.242	907.811
On table	12	867.276	849.510	849.418	794.853	818.232	809.811
On table	18	809.847	822.105	818.408	737.116	746.032	754.074
On table	24	751.786	736.357	727.337	708.253	712.095	697.126
On table	30	727.061	767.163	771.500	685.600	685.653	681.263
Under table	6	788.245	872.949	791.047	843.186	865.429	845.153
Under table	12	684.878	712.184	681.898	718.051	735.153	724.429
Under table	18	482.051	573.316	494.612	611.276	607.286	583.327
Under table	24	488.694	537.061	427.857	512.714	516.316	506.378
Under table	30	402.010	462.765	462.071	410.765	432.092	328.561