Adaptive Systems PG Lab Class.

By Ezequiel A. Di Paolo

Objectives

The following experiments involve a simple robot with 2 photoreceptors at the front and two motors. The robot is controlled by a continuous-time recurrrent neural network (CTRNN). The purpose of the practice is to explain the workings of the neural networks by performing behavioural experiments on the robot and by analytical methods. Three simple experiments are described below. Perform them and answer each point as indicated. If necessary you can perform experiments of your own devising. A series of questions is presented at the end; you must hand in your answers at the end of the class.

Advice: Be resourceful but systematic, go step by step, write down observations, test hypotheses.

Preliminaries

You will be given a simple code in C describing the neural network pictured in figure 1. Here SL and SR indicate the sensor readings for left and right sensors respectively calibrated for the range [0,1] where 1 means bright light. ML and MR indicate the signal fed into the left and right motors respectively.

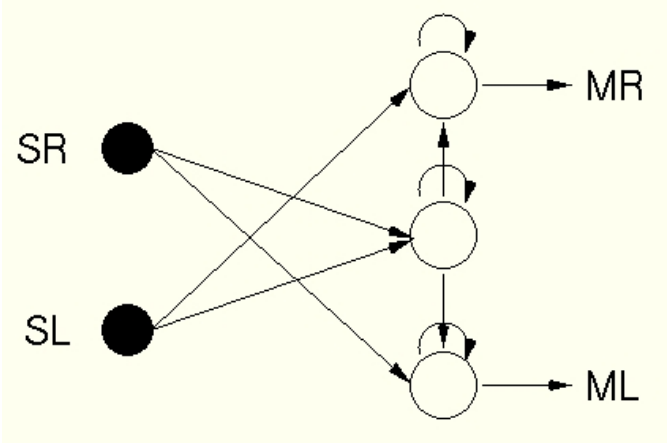

Figure 1. Robot CTRNN controller.

Each effective neuron (open circles) is governed by the following equation.

$$\tau_i \frac{dy_i}{dt} = -y_i + \sum_j w_{ji} z_j; \quad z_j = \frac{1}{1 + \exp[-(y_j + b_j)]},$$

Parameter values may be found in the C code.

Sensor calibration

It may be necessary to calibrate the sensors so that the input to the neural controller is 0 when the robot is sensing ambient light and 1 when a bright lamp is positioned near the sensors. There is code provided to do this. Once you estimated the corresponding readings, you can alter the upper and lower sensor readings in the code for the neural controller.

Experiment 1

Compile and download the controller into the robot. Turn the robot controller off. Lift the robot off the ground. Position a bright light directly in front of the robot for 10 seconds (measure it!). Now put the robot on the floor and observe its behaviour with respect to bright lights. Describe this behaviour in detail. Try to build a preliminary explanation of how the controller works.

Experiment 2

Reset the robot. Leave robot on the ground. Do not put any bright lights near the sensors for 10 seconds following resetting. Now observe the robot behaviour with respect to bright lights. Describe it in detail. If necessary, modify the explanation of how the controller works.

Experiment 3

Estimate the critical period of light presentation at the initial stage. Start as in experiment 2, wait for less than 10 seconds and then present a bright light to the robot. At what point (roughly) does the behaviour change?

Questions

Answer the following questions (you must hand in your answers).
1. What's your best explanation for how the controller works?
2. Why does the robot only make sharp turns?
3. Why is the robot unable to "recover" once a developmental trajectory has been set beyond a critical period? How would you modify the neural network so that the robot could "recover"?
4. What parameters would you modify if you wanted to extend or reduce the critical period? (Confirm this on the robot.)
5. Without performing the experiment, can you predict what would happen if the self connections were removed one-by-one from the 3 neurons? (Write down your predictions and then perform the experiment).
6. What is the minimum theoretical value of the self-connection in the middle neuron for the robot to behave as it does in the experiments?