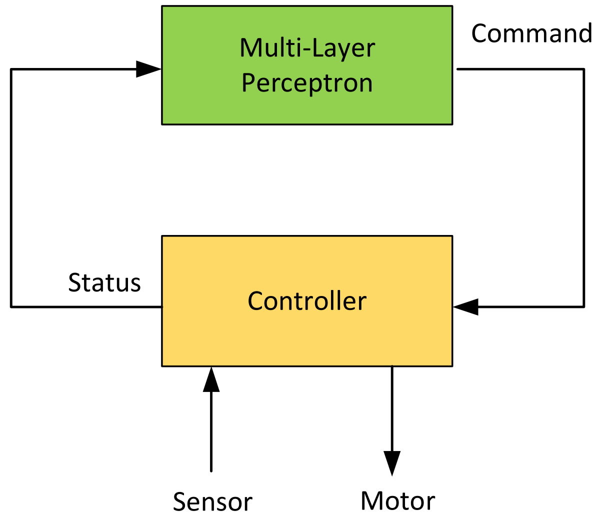
In this project you will build a fully-connected neural network (MLP) to provide some obstacle avoidance capability in a robot car. The controller receives the distance information from the sensor and sends the status to the MLP. The MLP supplies the command to the controller.



This pseudo code summarizes the functionality of the controller.

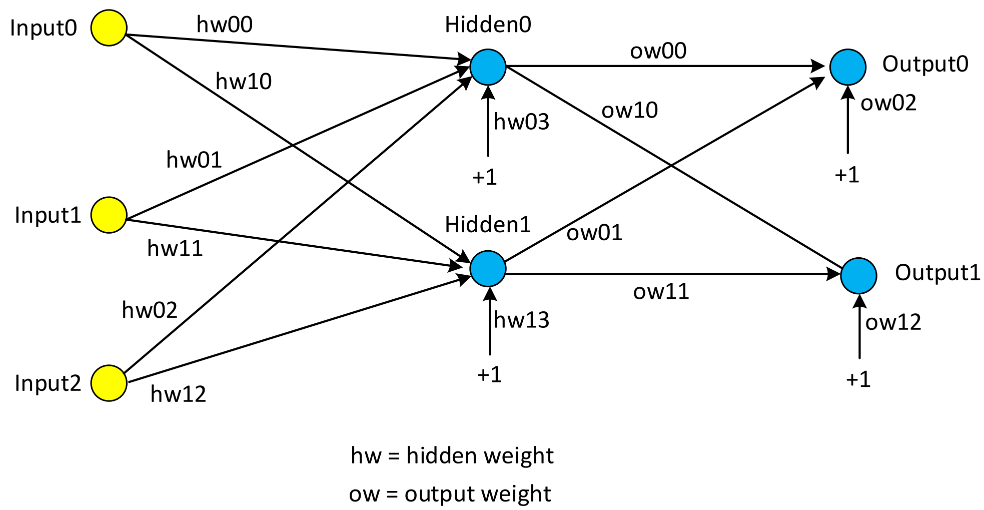
```
select command
        11 (Go Forward):
                if FrontDistance < OBSTACLE_DISTANCE
                        status = 001
                else
                        status = 000
        00 (Stop):
                go backward
                if LeftDistance > RightDistance
                        status = 010
                else
                        status = 100
        10 (Turn Left):
                turn left
                status = 000
        01 (Turn Right):
                turn right
                status = 000
```

In response, the MLP generates the following commands:

Status			Command		Remarks
Input 0	Input 1	Input 2	Output 0	Output 1	
0	0	0	1	1	No obstacle detected, go forward
0	0	1	0	0	Obstacle, stop and check left & right distances
0	1	0	1	0	Left distance is more, turn left
1	0	0	0	1	Right distance is more, turn right

Table 1

The MLP has 3 input nodes, 1 hidden layer with 2 neurons and 2 output neurons. All neurons use the sigmoid function as their activation functions.



With back-propagation use Table 1 to train the MLP.

Run for 15,000 epochs or until the error is less than 0.005. The error is defined as

$$\varepsilon = \frac{1}{2}\sum_{k=1}^{2} e_k^2 = \frac{1}{2}\sum_{k=1}^{2}(d_k - y_k)^2$$

Where d_k is the target value (command output) for output neuron k and y_k is the predicted value.

Randomize the dataset with each epoch.

Write the hidden weights and the output weights to a *csv* file called *MLP_weights.csv*. Your code should automatically download this file. You must organize the hidden weights and the output weights in the *csv* file as follows:

hw00	hw01	hw02	hw03
hw10	hw11	hw12	hw13
ow00	ow01	ow02	
ow10	ow11	ow12	

The TA will run *Verify_Weights.ipynb* to read the file and verify the output of your MLP. Table 2 shows the expected value of an output neuron.

Target	Output neuron
1	≥ 0.80
0	≤ 0.20

Table 2