CMPEN 497
Midterm FA20

Take Home: 10/22 – 10/27

*Student Name: ___________________________

*By signing my name to this midterm exam, I am indicating that I have adhered to the spirit and letter of the code of conduct as defined by the University and/or as listed in the course syllabus. I certify that I have neither requested nor received assistance in answering the questions in any form (written, verbal, electronic, etc.), neither specific nor implied. I understand that I will receive a zero for the exam and may receive a zero for the course if I fail to adhere to this code of conduct.

1. (5 pts) Model the perception of an autonomous vehicle's guidance system with a McCulloch-Pitts neural net. There is a visible light sensor feeding the guidance system with four possible states of traffic light states: red/yellow light = stop; green light = proceed straight; left green arrow = turn left; right green arrow = turn right. The guidance system prevents the vehicle from making two left or right turns in a row and prevents the car from going straight for more than 4 times in a row. Construct an M&P net that takes in the four states represented as a 2-bit output from the visible light sensor and show a random mix of 16 cases with runs of each possible signal combination (several left turns in arow, several right turns in a row, 5 go straight commands, and a mix of others). You must decide what your vehicle will do in the case when the system is presented with an exception as listed above. This will make your implementation unique to other students. The output states for the neural net will be one of four action states, each corresponding to one of four possible actions the vehicle could take at each intersection. Show all of your work neatly and logic state tables to clearly indicate the behavior and analysis of the net.

2. (4 pts) Consider a Hopfield network made up of five neurons, which is required to store the following three patterns:

   - $\mathbf{X}_1 = [1, 1, 1, 1, 1]^T$
   - $\mathbf{X}_2 = [1, -1, -1, 1, -1]^T$
   - $\mathbf{X}_3 = [-1, 1, -1, 1, 1]^T$

   a) Evaluate the 5x5 synaptic weight matrix for the network
   b) Use random updating to demonstrate that all three patterns satisfy the 'alignment condition' for the net (The asynchronous updating procedure continued until there were no further changes, i.e. starting with an input pattern, the network produces a time-invariant state vector **y** whose individual elements satisfy the condition $\mathbf{y} = \text{sgn}(\mathbf{W}^T\mathbf{x}_i) = \mathbf{x}_i$).
   c) Investigate the retrieval performance of the network when it is presented with a noisy version of $\mathbf{x}_2$ in which the second element in this input vector has its polarity reversed.

3. (8 pts) Perform pattern classification on the given training set data using the delta rule. The input layer consists of two neurons and the output layer is one neuron. The learning rate should change linearly from 0.9 to 1x10^-5 over the number of training sets; Run the training algorithm for 100 iterations/epochs.

   Present the following:

   - the neural network design
   - the final weight values
   - plot the MSE vs. epoch
   - calculate the classification error rate = (#errors/test points)
   - plot the test data and classification boundary on a single plot

4. (8 pts) Implement a Kohonen 1-D lattice driven by the provided 2-D stimulus data according to the following design guidelines:
   - 100 neurons
   - Initialize random weight vectors to be inside a region of x = [.25, .75] and y = [.25, .75]
   - Provide a plot of the SOM with connecting lines between nodes at:
     - t = 0 (initial random weights)
     - t = 10; 50; 100; 1,000; and 5,000
     - start with a learning rate of .5 and reduce it linearly over training period
     - training period is 100 iterations
     - R = 5 and reduce it linearly to 1 during the training phase