ENEE434 Spring 2003 Midterm Exam

100 points; 75 minutes, open book, open notes; if stuck go on to the next

1. [30 points, 25 minutes] (Perceptron)

Consider the classification problem defined below.

$$\left\{\mathbf{p}_1 = \begin{bmatrix} -1 \\ 1 \end{bmatrix}, t_1 = 1\right\} \left\{\mathbf{p}_2 = \begin{bmatrix} -1 \\ -1 \end{bmatrix}, t_2 = 1\right\} \left\{\mathbf{p}_3 = \begin{bmatrix} 0 \\ 0 \end{bmatrix}, t_3 = 0\right\} \left\{\mathbf{p}_4 = \begin{bmatrix} 1 \\ 0 \end{bmatrix}, t_4 = 0\right\}$$

(a) Design a single-neuron perceptron (specify weights and biases only) to solve this problem by applying the perceptron rule to the following initial parameters

$$\mathbf{W}(0) = [-1 \ 1] \quad \text{and} \quad b(0) = 0 .$$

Apply each input vector in order for as many repetitions as it takes to ensure that the problem is solved (i.e., the error is zero for every input).

(b) After you have found a final solution, graph the training data and the decision boundary of that solution.

Note: The transfer function to be used is hard limit function defined as

$$\text{hard lim}(x) = \begin{cases} 0 \, ; & x < 0 \\ 1 \, ; & x \geq 0 \end{cases}$$

2. [35 points, 20 minutes] (Discrete Time Hopfield Network)

Suppose that we want to distinguish between coconuts and baby monkeys. The prototype vectors are defined as follows

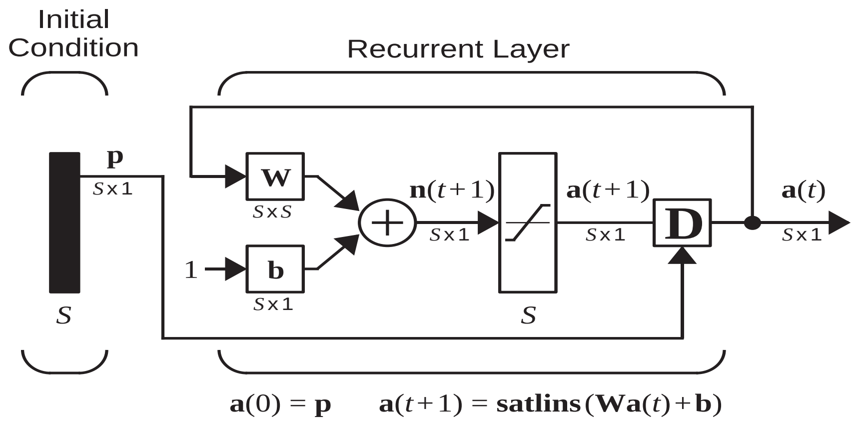
$$\mathbf{p}_1 = \begin{bmatrix} 1 \\ -1 \\ -1 \end{bmatrix} \text{ (coconut)} \qquad \mathbf{p}_2 = \begin{bmatrix} -1 \\ 1 \\ -1 \end{bmatrix} \text{ (monkey)}$$

(a) Design a Hopfield network, shown below, (specify weights and biases only) to recognize these patterns, using the Hebb rule.

(b) Take a not-so-perfect coconut,

$$\mathbf{p} = \begin{bmatrix} 2 \\ -2 \\ -0.4 \end{bmatrix},$$

to test this Hopfield network with weights and biases as designed in (a). Determine to which pattern the network converges.



Note: The transfer function to be used is symmetric saturating linear function defined as

$$\text{satlins}(x) = \begin{cases} -1\,; & x < -1 \\ x\,; & -1 \le x \le 1 \\ 1\,; & x > 1 \end{cases}$$

3. [35 points, 20 minutes] (Backpropagation)

For the network shown below the initial weights and biases are chosen to be

$$w^1(0) = 1,\ b^1(0) = -2,\ w^2(0) = 1,\ b^2(0) = 1.$$

The network transfer functions are

$$f^1(n) = \left(\frac{n}{3}\right)^2,\ f^2(n) = \frac{5}{n}\ ,$$

and an input/target pair is given to be

$$\left((p = 2), \left(t = \frac{1}{3}\right)\right).$$

Perform one iteration of backpropagation with learning rate, $\alpha = 0.7$.