Artificial Neural Networks
Programming Assignment 1

DUE DATE: NOV 30, 2019

OBJECT OF THE ASSIGNMENT:

To understand how the perceptron learning rule learns the weight and bias values for ***multiple-neuron perceptrons.***

PROBLEM:

Solve a four-category classification problem having two/three components in the input.

— Implement the perceptron learning rule for a ***two-neuron perceptron.***

— Implement the perceptron learning rule for a ***four-neuron perceptron.***

INPUT OF THE PROBLEM:

Training dataset/testing dataset

OUTPUT OF THE PROBLEM:

(a) Display ***weight/bias values*** of proper decision boundaries and ***the number of epochs*** when the perceptron learning rule converges; otherwise display the maximum number of epochs if proper decision boundaries are not found.

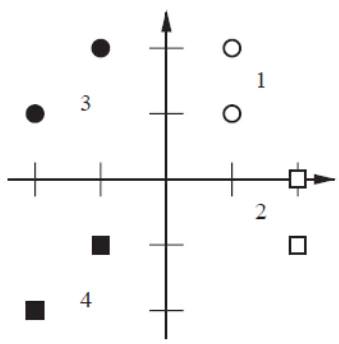
(b) Predict the classes (target vectors) of testing examples.

DATASETS:

(a) Dataset 1

This is a four-class classification problem described in Problem P4.3 in the textbook. Training data:

Training Pattern i		$\mathbf{p}_1$	$\mathbf{p}_2$	$\mathbf{p}_3$	$\mathbf{p}_4$	$\mathbf{p}_5$	$\mathbf{p}_6$	$\mathbf{p}_7$	$\mathbf{p}_8$
Neural Inputs	p_1	1	1	2	2	−1	−2	−1	−2
	p_2	1	2	−1	0	2	1	−1	−2
Target Values	t_1	0	0	0	0	1	1	1	1
	t_2	0	0	1	1	0	0	1	1



Testing data:

$$\mathbf{P}_9 = \begin{bmatrix} 5 \\ 2 \end{bmatrix}, \mathbf{P}_{10} = \begin{bmatrix} 0 \\ -2 \end{bmatrix}, \mathbf{P}_{11} = \begin{bmatrix} -1 \\ 1 \end{bmatrix}, \mathbf{P}_{12} = \begin{bmatrix} -3 \\ -4 \end{bmatrix}.$$

(b) Dataset 2

Suppose that we want to distinguish between watermelons, bananas, pineapples, and oranges, based on three sensor measurements (shape, texture, and weight).

Your TA will provide you a dataset containing 1000 training examples and another dataset containing 40 testing examples.

EXPERIMENTS:

(a) ***Two-neuron perceptron***:

(1) Dataset 1

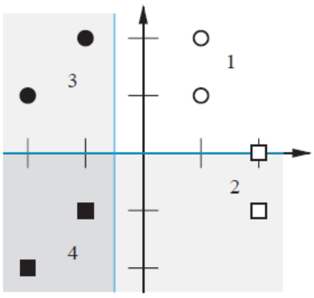
Begin your algorithm with the following initial weights and biases to train your perceptron network:

$$\mathbf{W} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, \; \mathbf{b} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}.$$

Expected output:

The ***weight/bias values*** of the final decision boundaries are:

$$\mathbf{W} = \begin{bmatrix} -2 & 0 \\ 0 & -2 \end{bmatrix}, \; \mathbf{b} = \begin{bmatrix} -1 \\ 0 \end{bmatrix}.$$



(2) Dataset 2 – Use the first two components. That is, shape and texture.

(3) Dataset 2 – Use the three components. That is, shape, texture, and weight.

(b) ***Four-neuron perceptron***:

(1) Run your ***four-neuron perceptron*** on Dataset 1.

Suppose that we change the target vectors to have four components. For example, the following table shows a possible mapping between two-neuron and four-neuron target vectors.

Target vectors of two-neuron	$[0\ 0]^T$	$[0\ 1]^T$	$[1\ 0]^T$	$[1\ 1]^T$
Target vectors of four-neuron	$[1\ 0\ 0\ 0]^T$	$[0\ 1\ 0\ 0]^T$	$[0\ 0\ 1\ 0]^T$	$[0\ 0\ 0\ 1]^T$

(2) Run your ***four-neuron perceptron*** on Dataset 2 and use the first two components.

(3) Run your ***four-neuron perceptron*** on Dataset 2 and use all of the three components.

REMARK: One variation of the perceptron learning rule is

$$\mathbf{W}^{new} = \mathbf{W}^{old} + \alpha \mathbf{e}\mathbf{p}^T$$

$$\mathbf{b}^{new} = \mathbf{b}^{old} + \alpha \mathbf{e}$$

where $\mathbf{e} = (\mathbf{t} - \mathbf{a})$ and α is called the learning rate (small positive value, e.g., 0.1).

DISCUSSION:

Summarize your results and discuss what your observations. For example:

— Compare the performance of your ***two-neuron perceptron*** and ***four-neuron perceptron***.

— Compare the performance of different initial weights/biases.

— Compare the performance of different learning rates.

— Everything else you consider it is important.