0907542 Patter Recognition (Spring 2015)
Midterm Exam

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Instructions: Time **60** min. Closed books & notes. No calculators or mobile phones. No questions are allowed. **Bold** case is used for vectors and matrices. Show your work clearly.

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Q1. Using Bayes classification rule, find the classification threshold point and classify the Point $x = 1.75$ given that:

[8 marks]

$$P(\omega_1) = 0.25, \quad P(\omega_2) = 0.75, \quad p(x|\omega_1) = x/2, \quad p(x|\omega_2) = 1 - x/2$$

The threshold is at

$$P(\omega_1)\, p(x|\omega_1) = P(\omega_2)\, p(x|\omega_2)$$

$$0.25 \times \frac{x}{2} = 0.75 \times (1 - \frac{x}{2})$$

$$\frac{x}{8} + \frac{3x}{8} = 3/4$$

$$\frac{4x}{8} = \frac{3}{4} \rightarrow x_0 = \frac{3}{2}$$

As $x = 1.75 > 3/2$ then x belongs to ω_1

Q2. Given the following four training samples belonging to classes $\boldsymbol{\omega_1}$ and $\boldsymbol{\omega_2}$:

$$\boldsymbol{\omega_1}: \begin{bmatrix}\mathbf{0}\\\mathbf{0}\end{bmatrix}, \begin{bmatrix}\mathbf{0}\\\mathbf{1}\end{bmatrix}, \qquad \boldsymbol{\omega_2}: \begin{bmatrix}\mathbf{1}\\\mathbf{0}\end{bmatrix}, \begin{bmatrix}\mathbf{1}\\\mathbf{1}\end{bmatrix}$$

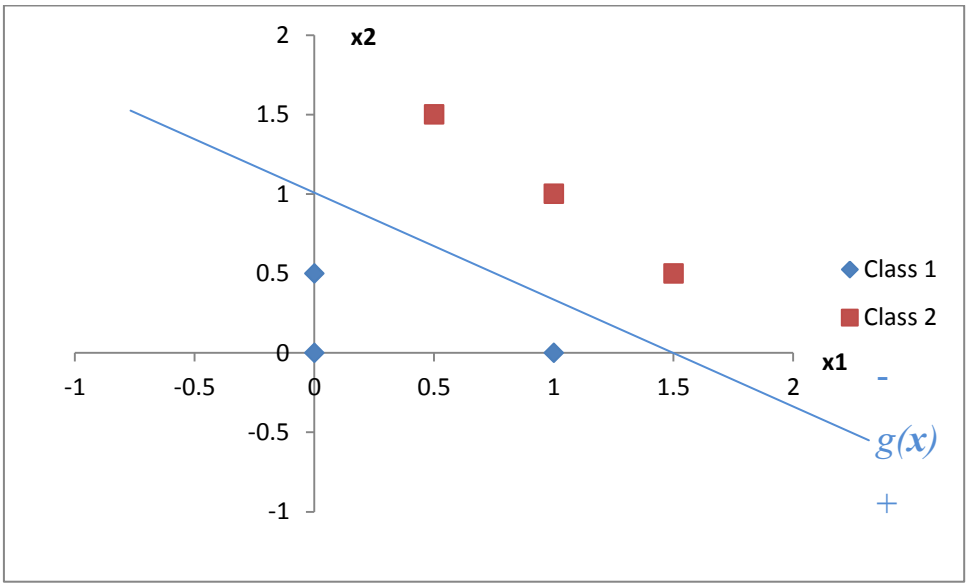
Using the Matlab `classify()` function, write the necessary Matlab code to classify the unknown sample $\boldsymbol{x} = [0.6 \quad 0.4]^T$.

[7 marks]

```
training = [0 0; 0 1; 1 0; 1 1];
group = ['Class 1'; 'Class 1'; 'Class 2'; 'Class 2'];
sample = [0.6 0.4];
classify(sample, training, group)
```

Q3. The following graph shows the feature values of 6 samples (three samples of Class 1 and three samples of Class 2).

[7 marks]



Design a perceptron network to classify these six samples (you must find the synaptic weights of your design and draw the resulting network).

Assume the decision line $g(\boldsymbol{x})$ as drawn above

$$g(\boldsymbol{x}) = w_1 x_1 + w_2 x_2 + w_0$$

Where $g(\boldsymbol{x}) > 0$ for Class1 and $g(\boldsymbol{x}) < 0$ for Class 2

To find the weights, let

$$g(\boldsymbol{x}) = w_1 x_1 + w_2 x_2 + w_0 = 0$$

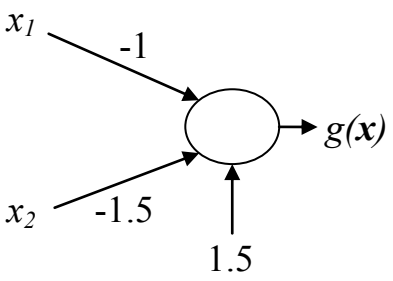
$$x_1 = 0 \rightarrow w_2 = -w_0/1.0$$

$$x_2 = 0 \rightarrow w_1 = -\frac{w_0}{1.5}$$

Let $w_1 = -1 \rightarrow w_0 = 1.5$

$$w_2 = -\frac{w_0}{1.0} = -1.5$$

Hence $g(\boldsymbol{x}) = -x_1 - 1.5x_2 + 1.5$



Q4. In a three-class recognition problem, find the value of $-\frac{1}{2}\boldsymbol{\mu}_2^T\boldsymbol{\Sigma}_i^{-1}\boldsymbol{\mu}_2$ given that $\boldsymbol{\Sigma}_i = 4\boldsymbol{I}$ and $\boldsymbol{\mu}_2 = [-1 \quad 1 \quad 2]^T$, where $\boldsymbol{I}$ is the identity matrix of size 3-by-3.

[8 marks]

$\boldsymbol{\Sigma}_i\boldsymbol{\Sigma}_i^{-1} = \boldsymbol{I}$

$4\boldsymbol{I}\boldsymbol{\Sigma}_i^{-1} = \boldsymbol{I}$

$\boldsymbol{\Sigma}_i^{-1} = \boldsymbol{I}/4$

$$-\frac{1}{2}\boldsymbol{\mu}_2^T\boldsymbol{\Sigma}_i^{-1}\boldsymbol{\mu}_2 = -\frac{1}{2}[-1 \quad 1 \quad 2]\left(\frac{\boldsymbol{I}}{4}\right)\begin{bmatrix}-1\\1\\2\end{bmatrix}$$

$$= -\frac{1}{8}[-1 \quad 1 \quad 2]\begin{bmatrix}-1\\1\\2\end{bmatrix}$$

$$= -\frac{1}{8}(1+1+4)$$

$$= -\frac{6}{8}$$

$$= -\frac{3}{4}$$

<Good Luck>