Mansoura University  
Faculty of Computer Science and information Systems  
Dept. of Information Systems  
Selected Topics (Neural Networks)  

Answer the following questions:

Question #1 [15 Marks]

(a) What is the difference between:
1. digital computers and neural networks?
2. biological and artificial neuron?
3. supervised and unsupervised learning?
4. feedforward and feedback neural networks?

(b) Design a neural network to perform the following mathematical operation:

\[ \Phi = \frac{2.5}{(1.2X + 1.3Y + 0.4)^3} + \frac{1.4}{\sqrt{0.5X + 2.6Y + 1.7}} \]

Draw the network structure, find the values of weights, and state the types of activation functions.

Question #2 [10 Marks]

A 2-2-2-1 feedforward neural network has the following weight specification:

between the input and first hidden layer:
w11=5  w12=2  w21=1  w22=-3

between the first and second hidden layer:
w11=3  w12=4  w21=-1  w22=6

between the second hidden layer and output layer:
w11=-2  w21=1

a) Draw the network structure.
b) Suppose that all neurons operate in their linear region. Write the input output mapping defining the network.
c) Assume that the activation function is sigmoid for all neurons. Write the input output mapping defining this new network.

Question #3 [10 Marks]

(a) What is the purpose of using activation function?

(b) For the following activation function:

\[ \Phi(x) = \frac{x}{\sqrt{1 + x^2}} \]

Show that the derivative of \( \Phi(x) \) with respect to \( x \) is given by:

\[ \frac{d\Phi}{dx} = \frac{\Phi^3(x)}{x^3} \]

What is the value of this derivative at the origin?
Question #3 [15 Marks]

Consider the pseudolinear activation function \( \Phi(x) \) shown in Fig. 1.

a) Formulate \( \Phi(x) \) as a function of \( x \).

b) What happens to \( \Phi(x) \) if \( a \) is allowed to approach zero?

\[ \Phi(x) \]

\[ \begin{align*}
\Phi(x) &= \begin{cases}
0.5b & \text{if } -0.5a < x < 0.5a \\
b & \text{if } x > 0.5a \\
0.5b & \text{if } x < -0.5a
\end{cases}
\]

Fig. 1

Question #4 [20 Marks]

a) A fully connected feedforward network has 10 source nodes, 2 hidden layers, one with 4 neurons and the other with 3 neurons, and a single output neuron. Construct an architectural graph of this network.

b) A feedback neural network has 3 source nodes, 2 hidden neurons, and 4 output neurons. Construct an architecture graph that describes such network.

c) Realize the following logic functions by using artificial neural networks:

1- AND  2- OR  3- NOT X + Y

Question #5 [15 Marks]

Consider 2-2-1 McCulloch-Pitts neural network with the following weight specification:

between the input and hidden layer:

\[ w_{11} = 1 \quad w_{12} = 2 \quad w_{21} = 1 \quad w_{22} = -1 \]

between the hidden layer and output layer:

\[ w_{11} = 2 \quad w_{21} = 2 \]

Each neuron has a threshold of 2.

a. Define the response of the output neuron in terms of the inputs \( X_1 \) and \( X_2 \).

b. Determine the output that results from an input signal \( X_1 = 1 \), and \( X_2 = 0 \).