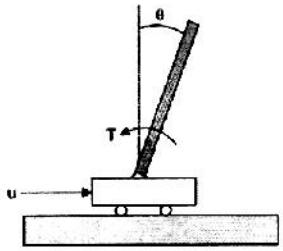
B.E. ELECTRONICS AND TELE-COMMUNICATION ENGINEERING FOURTH YEAR
FIRST SEMESTER - 2018

Subject: NEURO-FUZZY CONTROL Time: 3 Hours Full Marks: 100

Answer any FOUR.
All parts of the same question must be answered at one place only

1.(a) The linear differential equation of an inverted pendulum is given below.



$$\frac{4l}{3}\frac{4M+m}{4m}\ddot{\theta}-\frac{M+m}{m}g\theta=-\frac{u}{m}\frac{180}{\pi}$$

with $l=\frac{3(M+m)g}{4M+m}$ and $M=\frac{180}{\pi g}-m$

where m is the mass of the pole assumed to be concentrated at the center of the pendulum
M is mass of the cart
$2l$ is the length of the pendulum
θ is the deviation angle from vertical in the clockwise direction
T is the torque applied to the pole in the counterclockwise direction
u is the control on the cart acting from left to the right producing the counterclockwise torque T
t is time, and
g is the gravitational acceleration constant

(a) Define membership distributions of the state variables and the control output for $\theta(t) \in$ [−2 degree, 2 degree], $\dot{\theta}(t) \in$ [−4 dps, 4 dps] and $u(t) \in$ [−10, 10].

(b) Design the production rules for balancing the inverted pendulum in the vertical position.

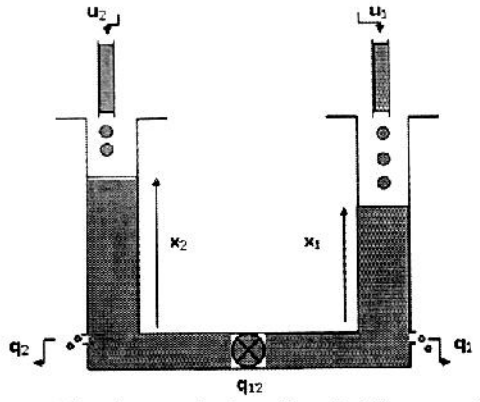
(c) From the designed membership distributions and proposed production rules, determine $u(0)$, $\theta(1)$ and $\dot{\theta}(1)$ for $\theta(0)$= 1 degree and $\dot{\theta}(0)$ = 0 dps.

7+8+10=25

2.(a) Define Takagi-Sugeno fuzzy control system.

(b) Explain the advantage of Takagi-Sugeno fuzzy control over Mamdani fuzzy control system.

(c) Design suitable fuzzy control system architecture of the following two-link tank system using Takagi-Sugeno model.



(d) Briefly explain different defuzzification methods with suitable examples.

6+3+10+6=25

3.(a) Explain the *K*-means clustering algorithm.

(b) What are the disadvantages of *K*-means clustering?

(c) How the impasse of *K*-means clustering can be overcome using fuzzy *C*-means (FCM) clustering algorithm? Give example.

(d) Derive the expressions of the cluster centroids and the memberships of data points in FCM.

8+3+4+10=25

4.(a) Prove that the perceptron learning always converges in a finite number of iteration.

(b) Explain the advantage of the LMS algorithm and gradient descent search induced weight and bias adaptation strategy of an ADALINE neuron over a perceptron learning policy.

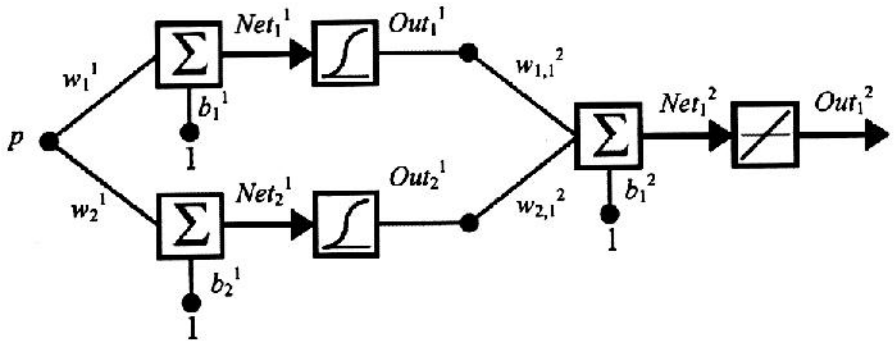
(c) Derive the expression for the optimal settings of the weights and the bias of a single ADALINE neuron for a given set of training data including the necessary constraints.

9+7+9=25

5.(a) Derive the expressions for adaptation of weights and biases in a multi-layer neural network using back-propagation learning algorithm.

(b) For the network shown below, the initial weights and biases are chosen to be

$$\vec{W}^1(0)=\begin{bmatrix}-0.27\\-0.41\end{bmatrix},\ \vec{b}^1(0)=\begin{bmatrix}-0.48\\-0.13\end{bmatrix},\ \vec{W}^2(0)=\begin{bmatrix}0.09\\-0.17\end{bmatrix},\ b^2(0)=0.48.$$



The network is used to approximate the function: $g(p) = 1 + \sin\left(\frac{\pi p}{4}\right)$.

Determine $\vec{W}^1(1)$, $\vec{b}^1(1)$, $\vec{W}^2(1)$ and $b^2(1)$ for $p = 1$ using backpropagation algorithm.

13+12=25

6.(a) What is a support vector machine (SVM)?

(b) How the goal of a SVM classifier can be formulated as an optimization problem with inequality constraints?

(c) How to modify the objective function to use the SVM classifier for non-separable classes.

(d) Simplify the objective function with inequality constraints obtained in the last step to a single objective function of Lagrangean multipliers.

(e) Explain the principle of non-linear classification using SVM.

2+3+7+9+4=25