School of Information Technology
IIT Kharagpur

Course Id: IT60108 Soft Computing Applications **End Sem Exam**
Date: April 25, 2008 **Total Time: 3 Hours**
Max. Marks: 100

Instructions: Answer any four questions. You may answer the questions in any order. However, all parts of the same question must be answered together. Clearly state any reasonable assumption you make.

1. Consider use of fuzzified Hough transform for generation of features to train an MLP with fuzzy input and output. Each pattern is of size 20×20. ρ varies as 0, 10 and 20 while θ varies as 0, 45 and 90. For 3 patterns P1, P2 and P3, let the Hough transform accumulators have the following values. Here comma separates the values for the three patterns.

ρ ⇒ θ ⇓	**0**	**10**	**20**
0	15, 2, 15	5, 15, 0	0, 10, 15
45	5, 15, 10	15, 15, 0	15, 10, 15
90	15, 5, 10	5, 15, 10	15, 0, 0

Define suitable membership functions for fuzzy sets: *Long Line* (LL), *Short Line* (SL), *Nearly Horizontal Line* (NH) and *Nearly Vertical Line* (NV). From these, define suitable membership functions for fuzzy sets *Nearly Vertical Long Line* (NVL), *Nearly Horizontal Long Line* (NHL), *Nearly Vertical Short Line* (NVS) and *Nearly Horizontal Short Line* (NHS). Next define suitable features from the fuzzy sets NVL, NHL, NVS and NHS. Finally, derive the actual inputs to the MLP by considering that for each feature coming from the fuzzy sets NVL, NHL, NVS and NHS, you need to generate membership into two fuzzy sets *High* and *Low*. Define suitable trapezoidal membership functions for *High* and *Low*.

From the above definitions of fuzzy sets, (a) clearly identify the MLP structure in terms of its number of inputs and outputs and (b) derive actual values of feature vectors for (i) input and (ii) desired output for training the MLP with each of the three patterns. Note that, you need not show any actual training and updating of weights. You simply need to show the inputs and corresponding desired outputs for each of the three patterns. **[7+[9+9]=25]**

2. Consider a multilayer perceptron (MLP) having 2 units in the input layer, 2 units in the hidden layer and one unit in the output layer. We want to train this MLP with the truth table of an **OR** gate. Let us denote the units in the input layer by the subscript **k**, those in the hidden layer by the subscript **j** and that in the output layer by the subscript **i**. Consider that the input layer to hidden layer weights are initially set as follows: w_{11}=2, w_{12}=1, w_{21}=2 and w_{22}=2. Hidden layer to the output layer wights are initially set as follows W_{11}=2 and W_{21}=1. Consider that the transfer functions for the hidden layer units as well as the output layer units are as follows:

$$\text{Output} = \frac{1}{1+e^{-Input}}$$

Assume that the input layer units transfer their inputs without any change and $\eta = 0.5$.

(a) Determine the new weights after an input pattern (1 0) is given as the training data. The expected output is 1.
(b) Consider that the transfer function for the hidden layer units is changed as follows, with the transfer function for the output layer remaining unchanged:

$$\text{Output} = \frac{1 - e^{-Input}}{1 + e^{-Input}}$$

Starting with the same initial weights, if we did the training, determine the new hidden layer to output layer weights for the same input pattern (1 0).

[10+15=25]

3. An optimization problem is to minimize the following function using SA:

$f(x1, x2) = (x1^2 + x2 - 1)^2 + (x1 + x2^2 - 3)^2$

x1 and x2 both belong to [0, 4]. Initial point is (2, 2) and initial temperature = 100. No. of iteration steps for each temperature = 2. Decrement temperature by a factor of 0.5. The neighboring points are to be chosen using a normal distribution of mean 0 and sigma = 0.833. Choose the numbers with normal distribution in the following sequence: 0.037, -0.086, -0.426, -1.210, 0.397, -0.312, 0.59, 0.21, -0.9, -0.3, 0.55, 0.45, -0.32, -0.98, 0.46, 0.12, -0.28, 0.97, -0.24, -.091, 0.28, -0.54, -0.21. If you need more numbers, keep repeating from the start of the list.

Show the result of optimization if we stop when temperature T reaches 25 (You do not need to show the calculation for T=25). **[25]**

4. Consider an optimization problem with the following two objective functions for minimization where x is a real number:

   $f_1(x) = x^2$
   $f_2(x) = (x - 2)^2$
   in the interval $-4 <= x <= 4$

Explain how you can solve it using MOGA (Fonseca and Fleming's method)

You need to choose sample chromosomes of your own for the first generation using the table given at the end of the question paper and show the results till the creation of the second generation. Length of the chromosomes should be 4 and population size = 8. You may use graph plotting to determine the dominated and non-dominated points. Use deterministic sampling as the selection operator. Consider crossover probability = 1.0 and there is no mutation. **[25]**

5. Consider the MLP training problem given in Q2 (with the first definition of transfer functions).
   (a) Show how MLP weight learning can be framed as an optimization problem to be solved using PSO.
   (b) Starting with an initial set of random weights and velocities, using PSO, determine the weights after the first iteration when an input pattern (1 0) is given as the training data. The expected output is 1. No. of particles to be taken = 4. Assume that all the weights would lie between 0 and 1. Clearly state any other assumption that you make. You need

to show all the updated pbest and gbest (both values and positions) after the first iteration. **[7+18=25]**

Use these Random Nos. for answering questions. If you need more, restart from Srl. No. 1.

Srl No.	Random No.	Srl No.	Random No.	Srl No.	Random No.	Srl No.	Random No.
1	0.2	16	0.4	31	0.9	46	0.2
2	0.4	17	0.8	32	0.1	47	0.3
3	0.7	18	0.8	33	0.2	48	0.2
4	0.2	19	0.6	34	0.2	49	0.7
5	0.1	20	0.5	35	0.3	50	0.8
6	0.3	21	0.1	36	0.7	51	0.5
7	0.8	22	0.9	37	0.8	52	0.5
8	0.9	23	0.2	38	0.7	53	0.6
9	0.1	24	0.3	39	0.5	54	0.7
10	0.2	25	0.4	40	0.4	55	0.3
11	0.5	26	0.5	41	0.5	56	0.4
12	0.7	27	0.4	42	0.3	57	0.8
13	0.8	28	0.6	43	0.8	58	0.4
14	0.9	29	0.7	44	0.2	59	0.5
15	0.4	30	0.2	45	0.1	60	0.6