INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR
Mid-Spring Semester Examination 2023-24

Date of Examination: 20.02.2024 Session: AN Duration: 02 hours Full Marks: 50

Subject No. : **CS 60108** Subject: **Soft Computing Applications** Computer Science & Engineering Department

Special instructions:
- *Answer to all questions.*
- *All symbols in the question, if not mentioned explicitly bear their usual meanings.*
- *You may make reasonable assumptions, if any.*
- *Non-programmable calculator may be allowed.*

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1. For a particular problem, consider a training set of size five as shown in Table 1.

#T	Input (I_1)	Input (I_2)	Output (O)
1	0.4	-0.7	0.1
2	0.3	-0.5	0.05
3	0.6	0.1	0.3
4	0.2	0.4	0.25
5	0.1	-0.2	0.15

   a) Decide a minimally configured Vanilla network that you should consider to build a prediction model with the given training data set. Justify the configuration (i.e., the number of perceptrons in each layer) of your proposed network.

   b) For the network, you have given compute the following.
      i. Output of the input layer
      ii. Input to the hidden layer
      iii. Output from the hidden layer
      iv. input to the output layer
      v. Output from the output layer

      Results of each layer computation should be expressed in matrix notation.

   c) Show the model parameters when the network got updated with any one training data. Show each step of the learning clearly.

[2.5 + 5×1 + 5 = 12.5]

2. In an automatic air conditioner controller, there is a sensor to sense room temperature. If temperature increases then the controller should increase the speed of the rotor of the compressor. If the speed of the compressor increases then it increases the speed of the fan. The above controller is designed with a fuzzy logic controller with the following three fuzzy sets.

T: temperature is High $\left\{\frac{0.3}{20}, \frac{0.7}{30}, \frac{0.8}{40}, \frac{1.0}{50}\right\}$

R: rotation is High $\left\{\frac{0.2}{20}, \frac{0.4}{40}, \frac{0.6}{60}, \frac{0.8}{80}, \frac{0.9}{100}, \frac{1.0}{120}\right\}$

S: fan speed is High $\left\{\frac{0.33}{500}, \frac{0.67}{1000}, \frac{0.95}{1500}, \frac{1.0}{2000}\right\}$

a) Given the above, compute the following rules

R1: If *temperature is High* Then *rotation is High*

R2: If *rotation is High* Then *fan speed is High*

b) Compute $R1 \circ R2$

c) Give the crisp value of the fuzzy value of fan speed when temperature is 40.

[5×1 + 2.5 + 2.5 = 10]

3. A smart washing machine is to be designed which would decide spin (the speed of the rotor in rotation per minute) and time of washing (in minutes), and detergent to be dispensed (in cc). The machine will decide the above based on the following three input (will be decided with appropriate sensors attached to the machine).
   - *Weight of the job:* Weigh is measurable in the range 0.5Kg to 6.0 Kg.
   - *Cloth type:* There are three types of clothes: cotton, woolen, and synthetic; each type of cloth is measurable in the 5 point Likert scale: 1, 2 ,..., 5 (where 5 is poor to 1 is impure).
   - *Pressure:* Water pressure is measurable in the range 1…6 Pascal.

   Given the above, answer to the following questions.
   a) What are the linguistic hedges you should consider to define each input and output fuzzily. Draw the membership function for each fuzzy input and output, which you may consider.
   b) How a fuzzy rule would look like in this case? . Give an example and illustrate your answer.
   c) How many total rules will be there in the rule base.
   d) Using the Takagi and Sugano approach, how a rule can be inferred? And how an output can be computed?

[5+2.5+2.5+5 = 15]

4. Following are the well-known activation functions to define a perceptron.
   - log-sigmoid function
   - tanh-sigmoid function
   - Radial bias function
   - Rectified linear unit function
   - Piecewise linear function

   a) Write down the expressions for the above mentioned activation functions.
   b) Clearly identify the parameters that control the transfer of input to output in each activation function.
   c) Draw the graph of each activation function and show how the graph changes with the change of parameter of the activation function.

[5×1 + 5× 0.5 + 5×1 = 12.5]

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