Indian Institute of Technology Patna

End-Semester Examination, Nov, 2024

Sub: Soft Computing Application in Engineering (ME-6122)

Full Marks: 70 **Time: 3 hours**

(Attempt ALL questions, Write answer in one place, number of pages 2)

Q1. Consider objective function $f(x) = (x_1 - 1)^2 + (x_2 - 1)^2$. Calculate the hessian matrix at (1, 1). Verify that hessian matrix is positive definite at this point. [5]

Q2. Proof the reduction in region (length) of golden section search is 38.2% of total region (length) remained. [5]

Q3. Consider the determination of the nearest integer value (in the range 0 to 15) of x that maximises the cost function

$$y(x) = -0.2x^2 + 1.5x$$

Use following four populations of four-bit chromosome, single site crossover of length 2, mutation probability of 25% for one iteration. Random number between 0 to 1 generated are 0.43, 0.63, 0.79 and 0.91.

Population	0011	0111	0001	1110

(a) copies of population generated in mating pool during reproduction using roulette wheel selection [9]

(b) off springs generated after crossover [4.5]

(c) which bit(s) is/are going to mute specify appropriately by rounding around it [4]

(d) fitness value of cost function before and after one iteration [2.5]

Q4. In a Sugeno FIS with four rule as given below [10]

Rule 1: If x is low and y is high then $z = 0.05x - 0.03y + 0.5$

Rule 2: If x is low and y is low then $z = y + 3$

Rule 3: If x is high and y is low then $z = x + 2$

Rule 4: If x is high and y is high then $z = 0.05x + 0.02y$

Where the input membership function are defined as

$\mu_{low}(x) = triangle(x; 1, 3, 7)$ $\mu_{high}(x) = triangle(x; 2, 4, 8)$

$\mu_{low}(y) = triangle(y; 0, 2, 4)$ $\mu_{high}(y) = triangle(y; 3, 5, 7)$

For a set of input $x = 5$ and $y = 5$, which set of rule will be fired. Calculate the output from FLC with above set of input.

Q5. With the help of a block diagram explain the working of a Mamdani fuzzy logic controller. [10]

Q6. Describe following [10]

(a) Saddle point

(b) Defuzzification

(c) Elitism

(d) technique to measure fuzziness in fuzzy set

(e) necessary condition and sufficient condition to have relative minima for Lagrange function

Q6. In a distillation process, objective is to separate component of mixture in the input stream. The relation between input and output is not precise. [10]

X=universe of temperature={160, 165, 170, 175, 180, 185, 190, 195}

Y=universe of distillation fraction ={77, 80, 83, 86, 89, 92, 95, 98}

We define a fuzzy set A and B on X and Y

A= Temperature of input stream is hot={(175, 0), (180, 0.7), (185, 1), (190, 0.4) }

B= Separation of mixture is good={(89, 0), (92, 0.5), (95, 0.8), (98, 1) }

We wish to determine proposition, if temperature of stream is hot then separation of mixture is good.

(a) find relation $R = (A \times B) U (\bar{A} \times Y)$

(b) If temperature of input stream is little hot defined by new fuzzy set

$A' = \{(170,1), (175, 0.8), (180, 0.5), (185, 0.2)\}$, using max- min composition, find

$B' = A' \circ R$

*****************Best of Luck*****************