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RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
Third Year - Semester II Examination – February/March 2019

COM3303 – ARTIFICIAL INTELLIGENCE

Time: THREE (3) hours

Instruction to Candidates:

01. This paper Contains **FOUR(4)** questions in **SIX(6)** pages.
02. Answer **ALL** four (4) questions in Part-A and Part-B.
03. Submit your answers for Part A and Part B in separate answer books.

Part - A

1. a) One arrangement (state) of four (4) queens in a 4x4 board of the well known n Queen problem in artificial intelligence is shown in figure 1. In this problem (game), the goal is to place the four queens on the board so that no two queens will share the same column, the same row or the same diagonal. A conflict occurs if any two queens violate any one of the rules specified above.
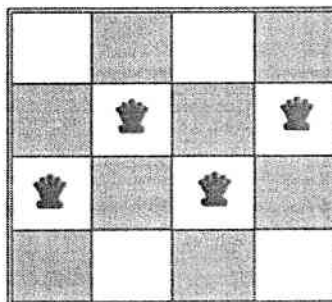

Figure 1. An initial state of four queens.

i. By copying this figure to your answer sheet, show that there are five (5) conflicts in this initial state. (Indicate each conflict with an arrow pointing to both queens involved in a conflict.

ii. Indicate in a similar diagram that an interim state with only two (2) conflicts can be achieved (without making the situation worse) by moving a single queen in one step.

iii. Hence show in a similar diagram that the goal can be achieved by moving a single queen in another (single) step.

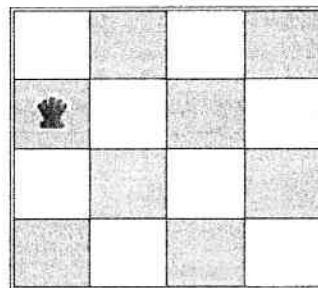iv. Consider the initial state with one queen in the left most column as shown in figure 2.

Figure 2. An initial state with one queen

Using relevant diagrams show that the goal state can be achieved by placing the other three queens one at a time in each column starting at the second column with each consecutive state having no conflicts.

v. Construct the relevant algorithm in pseudo code for the process in (iv) above.

[4 x 10 + 20 marks]

b) A road network with several cities is shown in figure 3. The problem is to find the shortest path from the start node (city **S**) to the Goal node (city **G**).
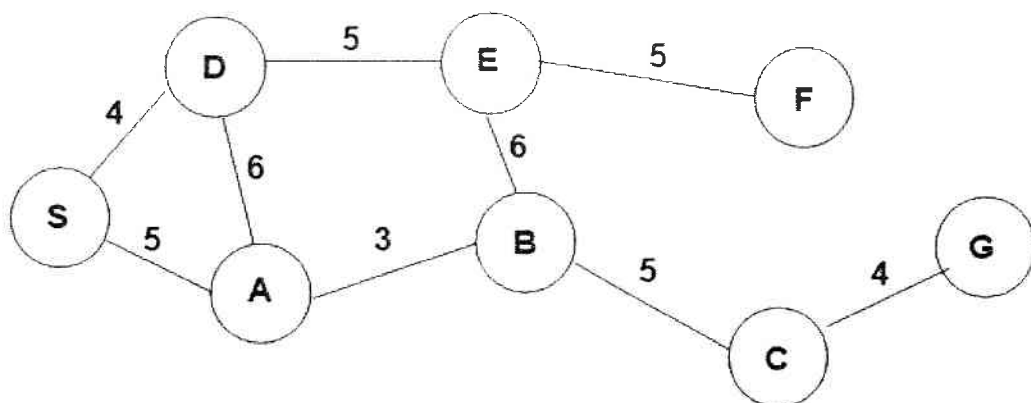

Figure 3. A road network

i. Show an example of a solution getting trapped in a cyclic loop. Explain briefly how such a situation can be avoided.

ii. Construct a State Space Tree for the above shortest path problem.

iii. By referring to the State Space Tree constructed in ii. above, construct the path of breadth-first-search up to the level 3 (excluding the root node).

iv. State and explain one strength and one weakness of breath-first search.

[5+20+5+10 marks]

2. a) Briefly explain how the following attributes are used to evaluate the performance of search algorithms:
   - Completeness
   - Optimality
   - Time complexity
   - Space complexity

[20 marks]

b) Using universal quantifiers ($\forall$ and $\exists$) where necessary, present the following in propositional logic

i. Gamini does not have brothers and sisters

iii. Kamala has at least two brothers

iv. Suresh is the grandfather of Malith

v. Everybody likes fruits

[30 marks]

c) A higher education institute has limited accommodation facilities for its students. Suitable students for accommodation facilities are selected from the eligible candidates based on the two parameters: Family Income and Distance to the institute from his/her permanent address (i.e. home). In order to automate the selection process for accommodation, a Fuzzy Logic based system has been proposed. The Fuzzy functions for each variable Family_Income (I), Distance_from_Home (D) and Score_for_Selection (S) are represented graphically in figures 4, 5 and 6 respectively.
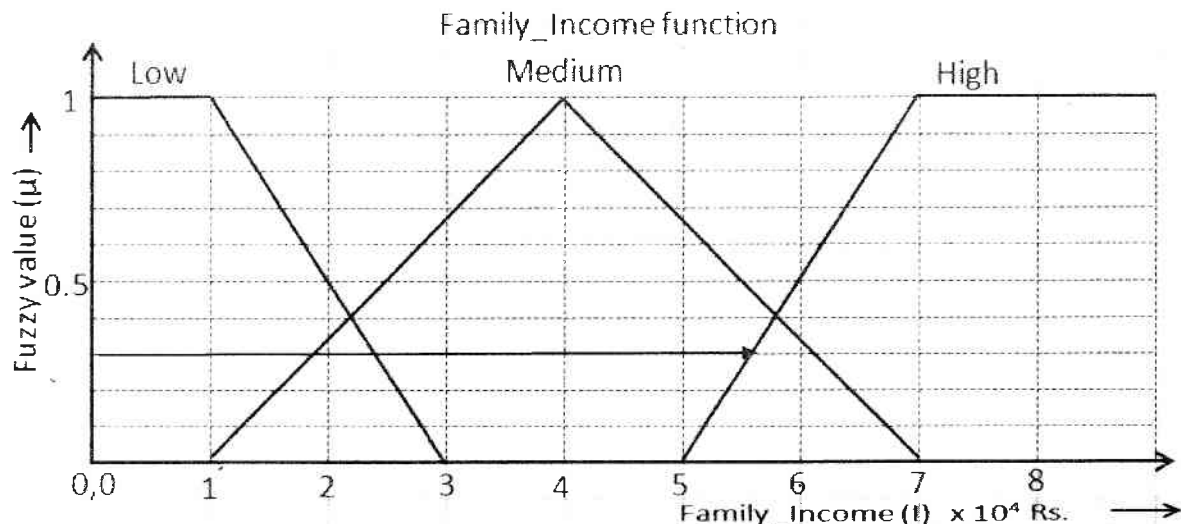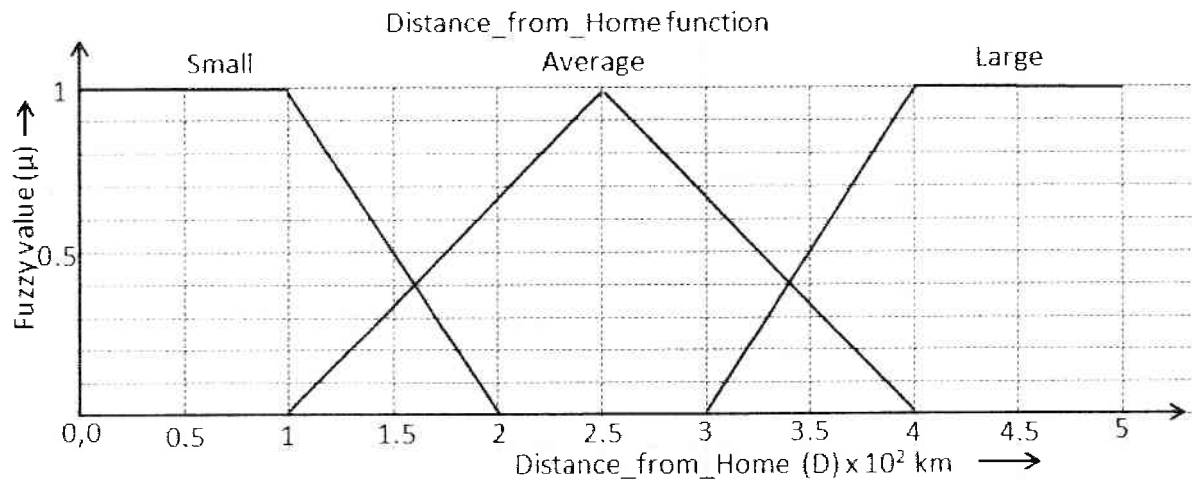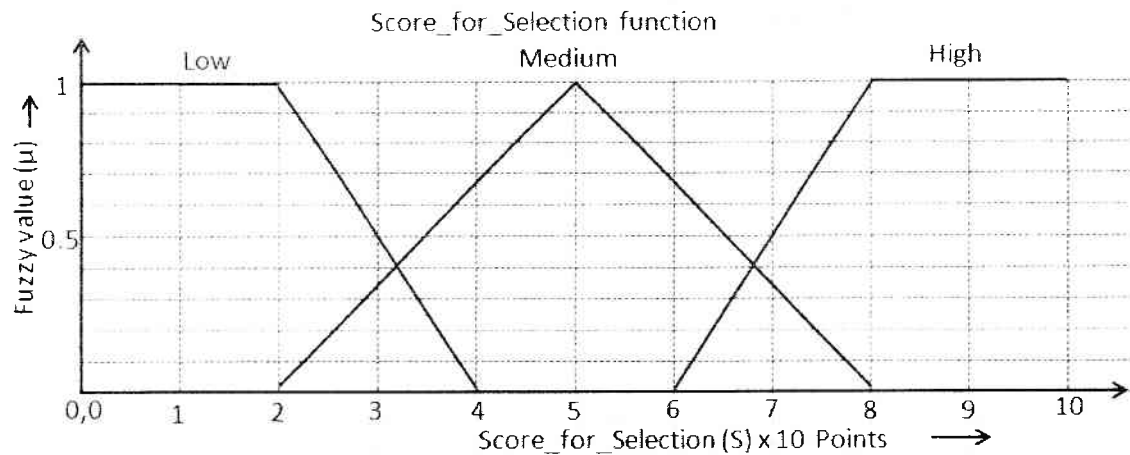
Family_Income function

Figure 4.

Figure 5

Figure 5

(i) What are the corresponding Fuzzy values for
  (1) Family_Income (I) = Rs. 55,000/-
  (2) Distance_from_Home (D) = 350 km

[10 marks]

(ii) What are the approximate values of I and D when $\mu = 0.3$?

[10 marks]

(iii) Several Fuzzy rules used in this scenario are:
  A. **if** *I is Low* **and** *D is Small* **then** *S is Medium*
  B. **if** *I is Low* **and** *D is Average* **then** *S is High*
  C. **if** *I is Low* **and** *D is Large* **then** *S is High*
  D. **if** *I is Medium* **and** *D is Small* **then** *S is Medium*
  E. **if** *I is Medium* **and** *D is Average* **then** *S is Medium*
  F. **if** *I is Medium* **and** *D is Large* **then** *S is Medium*
  G. **if** *I is High* **and** *D is small* **then** *S is Low*
  H. **if** *I is High* **and** *D is Average* **then** *S is Low*
  I. **if** *I is High* **and** *D is Large* **then** *S is Medium*

An eligible student has the following qualifications:
- *Family_Income* (I) = 2.5 x 10^4 Rs.
- *Distance_from_Home* (D) = 3.25 x 10^2 km

(1) What are the valid Fuzzy rules for this instance?

(2) Determine the *Score_for_Selection* (S) for the above student.

[20 marks]

(iv) Assuming that, the number of eligible students is higher than the number of places available for accommodation, explain briefly the relevance of *Score_for_Selection* for the selection process.

[10 marks]

Part- B

3. a) Name and describe three (3) main features of Genetic Algorithms (GA)   *[30 marks]*

b) Suppose a genetic algorithm uses chromosomes of the form *x = abcdefgh* with a fixed length of eight genes. Each gene can be any digit between 0 and 9. Let the fitness of individual *x* be calculated as:

$$f(x) = (a + b) - (c + d) + (e + f) - (g + h),$$

and let the initial population consist of four individuals with the following chromosomes:

$x_1 = 6\ 5\ 4\ 1\ 3\ 5\ 3\ 2$

$x_2 = 8\ 7\ 1\ 2\ 6\ 6\ 0\ 1$

$x_3 = 2\ 3\ 9\ 2\ 1\ 2\ 8\ 5$

$x_4 = 4\ 1\ 8\ 5\ 2\ 0\ 9\ 4$

i. Evaluate the fitness of each individual, showing all your workings, and arrange them in order with the fittest first and the least fit last.   *[20 marks]*

ii. Perform the following crossover operations: *[30 marks]*
   I. Cross the fittest two individuals using one–point crossover at the middle point.
   II. Cross the second and third fittest individuals using a two–point crossover (points *b* and *f*).
   III. Cross the first and third fittest individuals (ranked 1ˢᵗ and 3ʳᵈ) using a uniform crossover.

c) Suppose the new population consists of the six offspring individuals received by the crossover operations in the above question. Evaluate the fitness of the new population, showing all your workings. Has the overall fitness improved?   *[20 marks]*

4. a) What are the differences and similarities between the human brain and the machine? Discuss with the features of each of them. *[25 marks]*

   b) When does a neuron fire? *[25 marks]*

   c) What are the appropriate problem domains for neural network learning? *[25 marks]*

   d) Write short notes on the following. *[25 marks]*
      i. Supervised learning
      ii. Learning rate
      iii. Decision boundary
      iv. Multilayer perceptron (MLP)
      v. Activation function

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