NAME: AMEY MAHENDRA THAKUR

EXAM: SEMESTER - VII

SEAT NO.: 7278000

SUBJECT: AISC

DATE: 26-11-2021

Q.1 MCQs

1. D. Utility based agent
2. B. Unification
3. A. $\exists x$ glitters$(x) \wedge \neg$is-gold(x)
4. D. One
5. C. A, B, D, E, C, F, G
6. A. Forward state space search
7. B Crossword
8. A. $W_1 = 1$, $W_2 = 1$, $T = 1$
9. A. 238
10. B. Plateau

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Q2 A] (i)

N - Queen Problem

- N - Queen problem is based on chess game
- The problem is based on arranging the queens on chessboard in such a way that no two queens can attack each other.
- The N - Queen problem states as consider a N x N chessboard on which we have to play n queens so that no two queens attack each other being in the same row or in the same column or on the same diagonal

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Example: $N = 4$

1. Let us take the example of 4 - Queens and 4×4 chessboard
2. Start with an empty chessboard
3. Place Queen 1 in the first possible option of its row. i.e. on 1st row 1st column.

Q			

4. Then place Queen 2 after trying unsuccessful place (1,2), (2,1), (2,2), at (2,3) i.e. 2nd row and 3rd column

Q			
		Q	

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(5) This is a dead end because a 3rd queen cannot be placed in next column, as there is no acceptable position for queen 3. Hence algorithm back tracks and places the 2nd queen at (2,4) position.

Q			
			Q

(6) Then place 3rd queen at (3,2) but it again another dead lock end as next queen (4th queen) cannot be placed at permissible position.

Q			
			Q
	Q		

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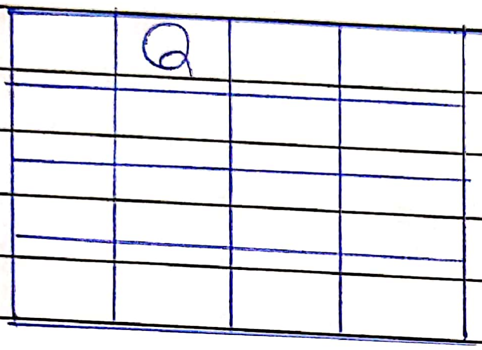
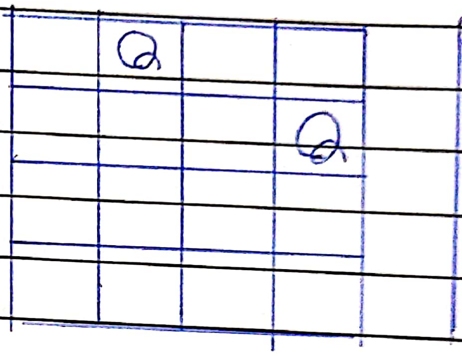
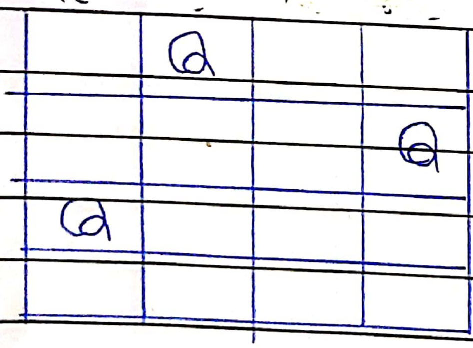
(7) Hence we need to backtrack all the way up to queen 1 and move it to (1,2).

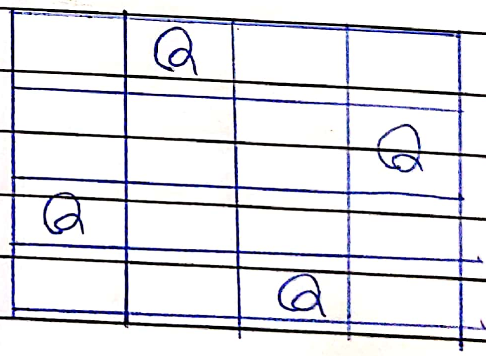
(8) Place Queen 1 at (1,2), queen 2 at (2,4), queen 3 at (3,1) and Queen 4 at (4,3)





(9) Thus the solution is obtained (2,4,1,3) in row





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Q.2 A] (ii)

PEAs

- PEAS stands for Performance, Environment, Actuators and Sensors.
- Based on these properties of an agent, they can be grouped together or can be differentiated from each other.
- Each agent has these following properties defines for it.

① Performance Measure (P)
- It specifies the performance expected by the agent.

② Environment (E)
- It specifies the surrounding condition where the agent has to perform a task.

③ Actuators (A)
- It specifies the tool available for the agent to complete the task.

④ Sensors (S)
- It specifies the tool required to sense the work environment.

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PEAS for Robot meant for cleaning the house.

① Performance Measure (P)

- Maximize energy consumption, maximize Dirt Pick up, Percentage of precision of cleaning.

② Environment (E)

- House, Dirt distribution unknown, assume actions are deterministic and environment is static.

③ Actuators (A)

- Joined arm and hand, view detector for robot left, right, suck and NoOp.

④ Sensors (S)

- Camera, orientation & Touch sensors, sensors to identify the dirt and potentiometric sensor.

Environment

- Partially Observable, stochastic, Sequential, Dynamic, Continuous and Multi Agent.

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Q2 A] iii)

$X = \{a, b, c\}$

$Y = \{1, 2, 3\}$

$A = \{(a, 0.1), (b, 0.6), (c, 0.1)\}$

$B = \{(1, 0.3), (2, 0.2), (3, 1.0)\}$

To find: If x is A then y is b.

Soln:

$$A \times B = \begin{array}{c} \\ a \\ b \\ c \end{array} \begin{array}{c} \begin{array}{ccc} 1 & 2 & 3 \end{array} \\ \begin{bmatrix} 0.1 & 0.1 & 0.1 \\ 0.3 & 0.2 & 0.6 \\ 0.1 & 0.1 & 0.1 \end{bmatrix} \end{array}$$

$$\bar{A} \times B = \begin{array}{c} \\ a \\ b \\ c \end{array} \begin{array}{c} \begin{array}{ccc} 1 & 2 & 3 \end{array} \\ \begin{bmatrix} 0.3 & 0.2 & 0.4 \\ 0.3 & 0.2 & 0.4 \\ 0.3 & 0.2 & 0.4 \end{bmatrix} \end{array}$$

$$R_{mm} = (A \times B) \cup (\bar{A} \times B) = \begin{array}{c} \\ a \\ b \\ c \end{array} \begin{array}{c} \begin{array}{ccc} 1 & 2 & 3 \end{array} \\ \begin{bmatrix} 0.3 & 0.2 & 0.4 \\ 0.3 & 0.2 & 0.6 \\ 0.3 & 0.2 & 0.4 \end{bmatrix} \end{array}$$

The R represents if x is A then y is B.

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Q2 B (ii)

ANFIS

- ANFIS stands for Adaptive Neuro Fuzzy Inference System.
- It is a kind of artificial neural network that is based on Takagi - Sugeno Fuzzy inference system.
- ANFIS was introduced by Jang.
- ANFIS is used for modelling, controlling and parameter estimation in complex systems.
- ANFIS is a combination of artificial neural network (ANN) and Fuzzy Inference System (FIS).
- Combining the ANN and fuzzy-set theory can provide advantages and overcome the disadvantages in both techniques.

Features of ANFIS

- It refines fuzzy IF-THEN rules to describe the behavior of a complex system.
- It does not require prior human expertise.
- It is easy to implement.
- It enables fast and accurate learning
- It offers desired data set; greater choice of membership functions to use; strong generalization abilities; excellent explanation facilities through fuzzy rules.
- It is easy to incorporate both linguistic and numeric knowledge for problem solving.

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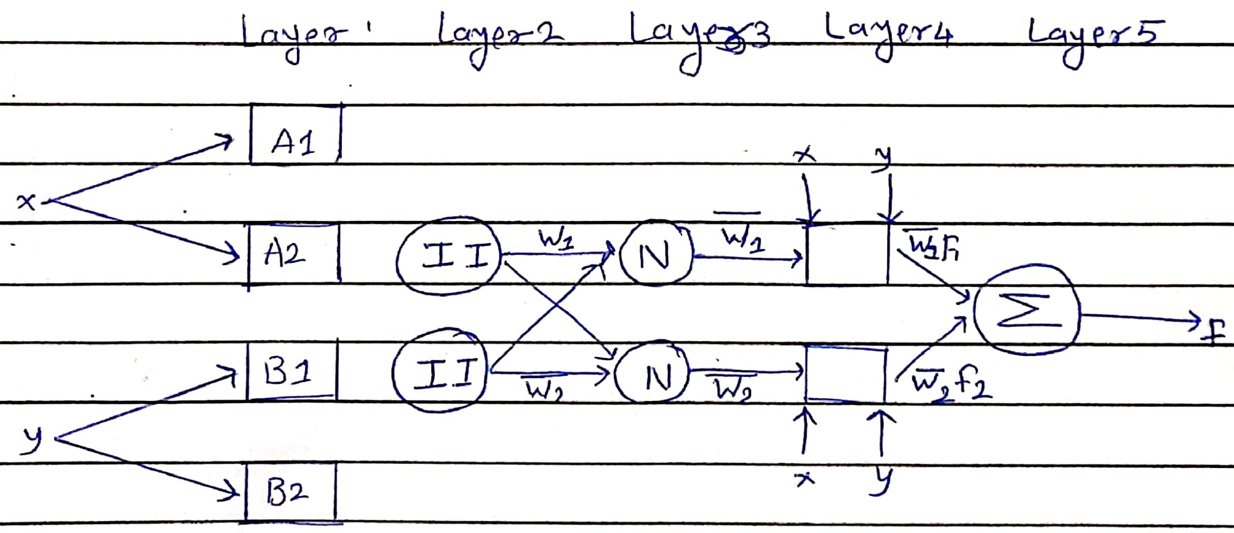
ANFIS Architecture

- In order to explain the ANFIS architecture, we assumed that there are two inputs x and y
- Two fuzzy if-then rules for a first order Sugeno fuzzy model can be expressed as follows:

Rule 1 - If x is A_1 and y is B_1, then $f_1 = p_1 x + q_1 y + r_1$

Rule 2 - If x is A_2 and y is B_2, then $f_2 = p_2 x + q_2 y + r_2$.

- Where A_i and B_i are the fuzzy sets, f_i is the output and p_i, q_i and r_i are the design parameters that are determined during the training process.
- The ANFIS architecture used to implement the 2 rules



ANFIS Architecture with two inputs, one output and two rules.

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- The structure of ANFIS includes five layers that can be explained as follows:
  where O_i^j represent the output of the ith node and jth layer.

① Layer 1

- In this layer, each node represents a node function,

$$O_i^1 = \mu A_i(x); \quad \text{for } i = 1, 2$$

- Where x is the input to the ith node.
  A_i is the linguistic label (cold warm etc.) chararacterized by proper membership function.

② Layer 2

- In this layer, each node calculates the firing strength of a rule by multiplication:

$$O_i^2 = W_i = \mu A_i(x) * \mu B_i(y), \quad i = 1, 2.$$

③ Layer 3

- In this layer, firing strengths that were evaluated in the previous layer are normalized to distinguish between the firing strength of each rule from the total firing strengths of total rules

$$O_i^3 = \overline{W_i} = \frac{W_1}{W_1 + W_2}, \quad i = 1, 2$$

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(4) Layer 4

- In this layer, node i calculates the contribution of i^{th} rule to the overall output.

$$O_i^4 = \overline{w_i} * f_i = \overline{w_i} (p_i * x + q_i * y + r_i)$$

where $\overline{w_i}$ is the output of layer 3 and the parameter set is $\{p_i, q_i, r_i\}$.

(5) Layer 5.

- In this layer, the single node calculates the overall output as the total contribution from each rule:

$$O_i^5 = \sum_i \overline{w_i} * f_i = \frac{\sum_i w_i * f_i}{\sum_i w_i}$$

- The ANFIS has two learning algorithms. back propagation and hybrid methods, which try to minimize the error between the observed and predicted data.

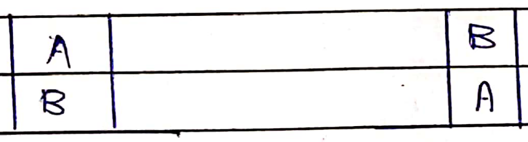
Q3 A] (i)

Partial Order Planner

- Planning is the process of thinking about and organizing the activities required to achieve a desired goal.
- Any planning algorithm that can place two actions into a plan without specifying which comes first is called as a Partial Order Planner.
- A partial order planner searches through plane space.
- It starts with an initial plan representing the start and finishing steps, and on each iteration adds one more step.
- If it leads to incomplete plan, it backtracks and tries another branch of search space.
- The solution is represented as a graph of actions, not a sequence of actions.

Example:

Let us define following two macros for the sake of simplicity for block world example.



Initial state Goal

Partial order planning block world example

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Note: MOT (Move on Table)

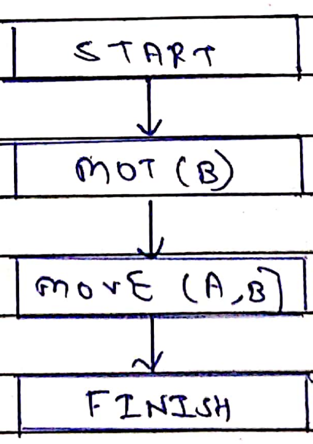
Macro operator	Description
MOT (A)	Move A onto table
MOVE (B, A)	Move B onto A

To achieve the Goal state ON (A, B)

1. Move 'A' onto table should occur before move 'B' to 'A'.
2. Hence, MOT (A) should come before MOVE (B, A) in the Final Plan.

Partial Order Planner Graph

- It contains the dummy actions START & FINISH to mark the beginning and end of the plan in the graph.
- The planner can generate total plans from the graph.



Partial Order Planning Graph

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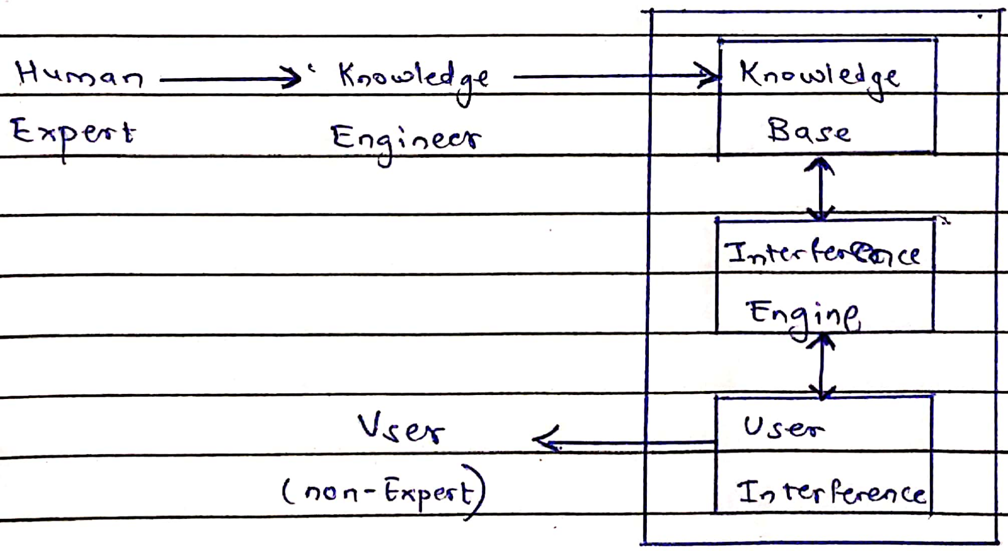
Q3 A] (ii)

Expert System

- Expert system are Artificial Intelligence (AI) tools.
- It capture the expertise of knowledge workers (Experts) and provide advice to usually non-experts in a given domain.
- In artificial intelligence, an expert system is a computer system that emulates the decision-making ability of a human expert.
- Expert systems are designed to solve complex problems by reasoning about knowledge, represented primarily as if-then rules rather than through conventional procedural code.
- Expert system are implemented with artificial intelligence technology, often called Expert system Shells.

Architecture of Expert System.



Expert System Architecture

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Characteristics of Expert Systems

1. High Performance
2. Understandable
3. Reliable
4. Highly Responsive

Components

1. Knowledge Base
   - Knowledge Base is database of rules.
   - It contains domain - specific and high quality knowledge.
   - Knowledge is required to exhibit intelligence
   - The success of any Expert System majorly depends upon the collection of highly accurate and precise knowledge.

2. Interface Engine
   - Interface engine acquires and manipulates the knowledge from the knowledge base to arrive at a particular solution.
   - Interface engine use Forward & Backward chaining strategies.

3. User Interface
   - User interface provides interaction between user of the Expert system and the Expert System itself.
   - It is generally Natural Language Processing, so as to be used by the user who is well.-versed in the task domain

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Advantages

① Availability : They are easily available due to mass production of software.

② Less Production Cost: Production cost is reasonable. This makes them affordable.

③ Speed : They offer great speed. They reduce the amount of work an individual puts in.

④ Less Error Rate: Error rate is low as compared to human errors.

⑤ Reducing Risk: They can work in the environment dangerous to humans.

⑥ Steady response: They work steadily without getting motional, tensed or fatigued.

Disadvantages

- No technology can offer easy and complete solution. Large systems are costly, require significant development time and computer resources.
  ESs have their limitations which include -

① Limitations of the technology.
② Difficult knowledge acquisition
③ ES are difficult to maintain
④ High development costs.

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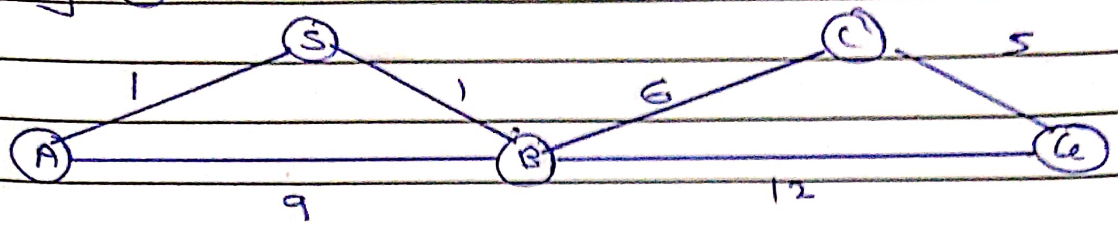
Q3 B (i)



$h(S) = 7$, $h(A) = 10$, $h(B) = 9$, $h(C) = 5$, $h(G) = 0$

Soln:

(1) Step 1: $f(n) = h(n) + g(n)$

Expand node S

$S \rightarrow A = 1 + 10 = 11$

$S \rightarrow B = 1 + 9 = 10$

(2) Step 2: Since cost of $S \rightarrow B$ is less. we will select that path

Expand node B

$S \rightarrow B \rightarrow C = 1 + 6 + 5 = 12$

$S \rightarrow B \rightarrow G = 1 + 12 + 0 = 13$

$S \rightarrow A = 10$

(3) Step 3: Expand node A

$S \rightarrow A \rightarrow B = 1 + 9 + 9 = 19$

$S \rightarrow B \rightarrow C = 12$

(4) Step 4: Expand Node C

$S \rightarrow B \rightarrow C \rightarrow G = 1 + 6 + 5 + 0 = 12$

$S \rightarrow A + B = 19$

The optimal path is -

$S \rightarrow B \rightarrow C \rightarrow G$ Cost = 12 units

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Q3 B] (ii)

U = Flowers = { Jasmine, Rose, Lotus, Daffodil, Sunflower, Hibiscus, Lily }

$P = \frac{0.3}{Jasmine}, \frac{0.9}{Rose}, \frac{1.0}{Lotus}, \frac{0.7}{Daffodil}, \frac{0.5}{Sunflower}, \frac{0.4}{Hibiscus}, \frac{0.6}{Lily}$

$Q = \frac{1.0}{Jasmine}, \frac{1.0}{Rose}, \frac{0.5}{Lotus}, \frac{0.2}{Daffodil}, \frac{0.2}{Sunflower}, \frac{0.1}{Hibiscus}, \frac{0.4}{Lily}$

To find: $P \cup Q$, $P \cap Q$, P', Q', $P - Q$, $P' \cap Q'$

Sol^n:

$P \cup Q = \frac{1.0}{Jasmine} + \frac{1.0}{Rose} + \frac{1.0}{Lotus} + \frac{0.7}{Daffodil} + \frac{0.5}{Sunflower} + \frac{0.4}{Hibiscus} + \frac{0.6}{Lily}$

$P \cap Q = \frac{0.3}{Jasmine} + \frac{0.9}{Rose} + \frac{0.5}{Lotus} + \frac{0.2}{Daffodil} + \frac{0.2}{Sunflower} + \frac{0.1}{Hibiscus} + \frac{0.4}{Lily}$

$P' = \frac{0.7}{Jasmine} + \frac{0.1}{Rose} + \frac{0}{Lotus} + \frac{0.3}{Daffodil} + \frac{0.5}{Sunflower} + \frac{0.6}{Hibiscus} + \frac{0.4}{Lily}$

$Q' = \frac{0}{Jasmine} + \frac{0}{Rose} + \frac{0.5}{Lotus} + \frac{0.8}{Daffodil} + \frac{0.8}{Sunflower} + \frac{0.9}{Hibiscus} + \frac{0.6}{Lily}$

$P - Q = P \cap Q'$

$= \frac{0}{Jasmine} + \frac{0}{Rose} + \frac{0.5}{Lotus} + \frac{0.7}{Daffodil} + \frac{0.5}{Sunflower} + \frac{0.4}{Hibiscus} + \frac{0.6}{Lily}$

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$$P' \cap Q' = \underset{\text{Jasmine}}{\underline{0}} + \underset{\text{Rose}}{\underline{0}} + \underset{\text{Lotus}}{\underline{0}} + \underset{\text{Daffodil}}{\underline{0.3}} + \underset{\text{Sunflower}}{\underline{0.5}} + \underset{\text{Hibiscus}}{\underline{0.6}} + \underset{\text{Lily}}{\underline{0.4}}$$

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Q 4 A] (i)

If two people are friends, then they are not enemies

$$\forall x \forall y \, (\text{Friend}(x,y) \implies \neg \text{Enemy}(x,y))$$

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Q4 A (ii)

Membership Function

- Membership functions were first introduced in 1965 by Lofti A. Zadeh in his first research paper "fuzzy sets".
- A function that specifies the degree to which a given input belongs to a set is known as Membership Function.
- Membership functions characterize fuzziness, whether the elements in fuzzy sets are discrete or continuous.
- Membership functions are used in the fuzzification and defuzzification steps of a FLS (Fuzzy Logic System), to map the non-fuzzy input values to fuzzy linguistic terms and vice versa.
- Membership functions are represented by graphical forms.

Types of Membership Function

1. Increasing MFs (Γ Function)
2. Decreasing MF (L Function)
3. Triangular MF (∧ Function)
4. Trapezoidal MF (π Function)
5. Gaussian MFs
6. Generalized Bell MF / Cauchy MF
7. Sigmoidal MFs

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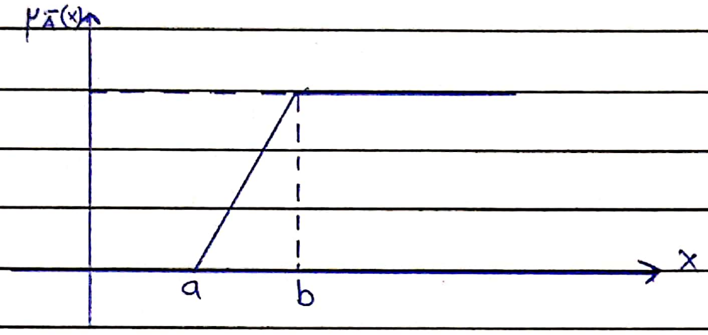
Types of membership function

① Increasing MFs (T Function):

- An increasing MF is specified by two parameters (a, b) as follows.

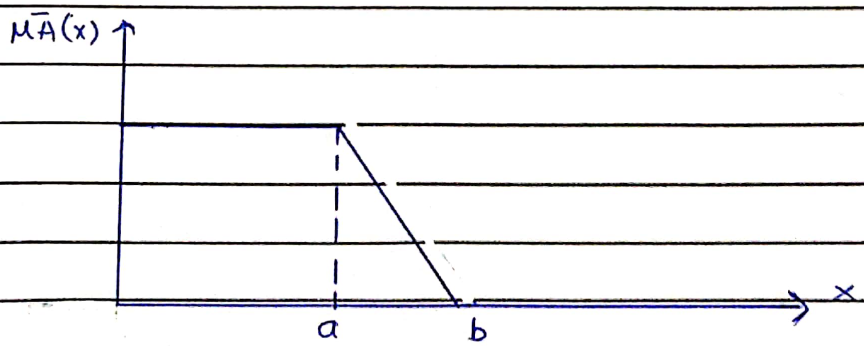
$$T(x; a, b) = \begin{cases} 0 & ; \quad x \leq a \\ (x-a)/(b-a) & ; \quad a \leq x \leq b \\ 1 & ; \quad x \geq b \end{cases}$$



② Decreasing MF (L Function):

- A decreasing MF is specified by two parameters (a, b) as follows:

$$L(x; a, b) \begin{cases} 1 & ; \quad x \leq a \\ (b-x)/(b-a) & ; \quad a \leq x \leq b \\ 0 & ; \quad x \geq b \end{cases}$$



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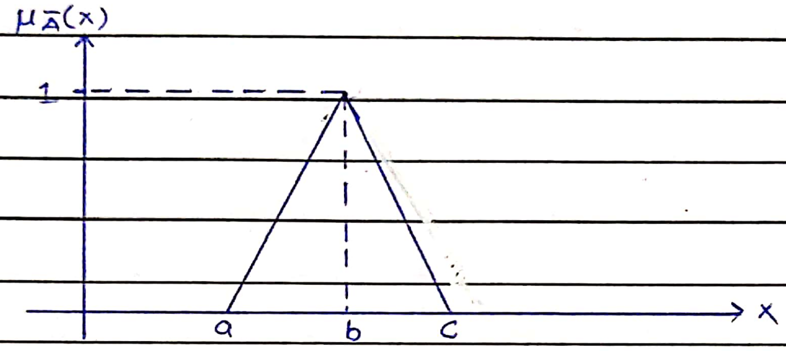
③ Triangular MF (∧ Function)

- A triangular MF is specified by three parameters (a, b, c) as follows:

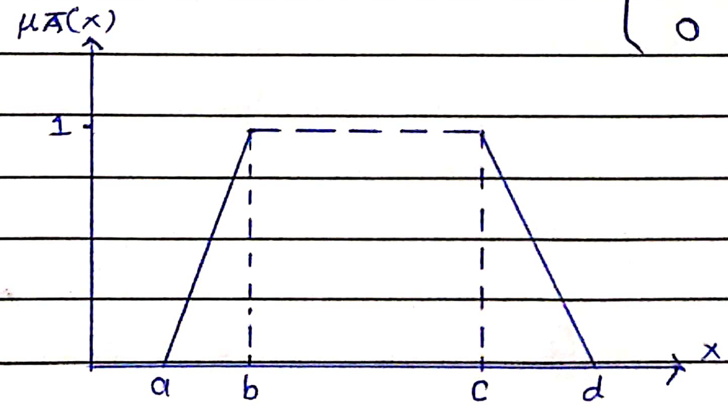
$$\wedge(x; a, b, c) = \begin{cases} 0 & ; \; x \le a \\ (x-a)/(b-a) & ; \; a \le x \le b \\ (c-x)/(c-b) & ; \; b \le x \le c \\ 0 & , \; x \ge c \end{cases}$$



④ Trapezoidal MF (π function):

- A Trapezoidal MF is specified by four parameters (a, b, c, d) as follows:

$$\text{Trapezoid}(x; a, b, c, d) = \begin{cases} 0 & , \; x \le a \\ (x-a)/(b-a) & , \; a \le x \le b \\ 1 & , \; b \le x \le c \\ (d-x)/(d-c) & , \; c \le x \le d \\ 0 & , \; x \ge d. \end{cases}$$



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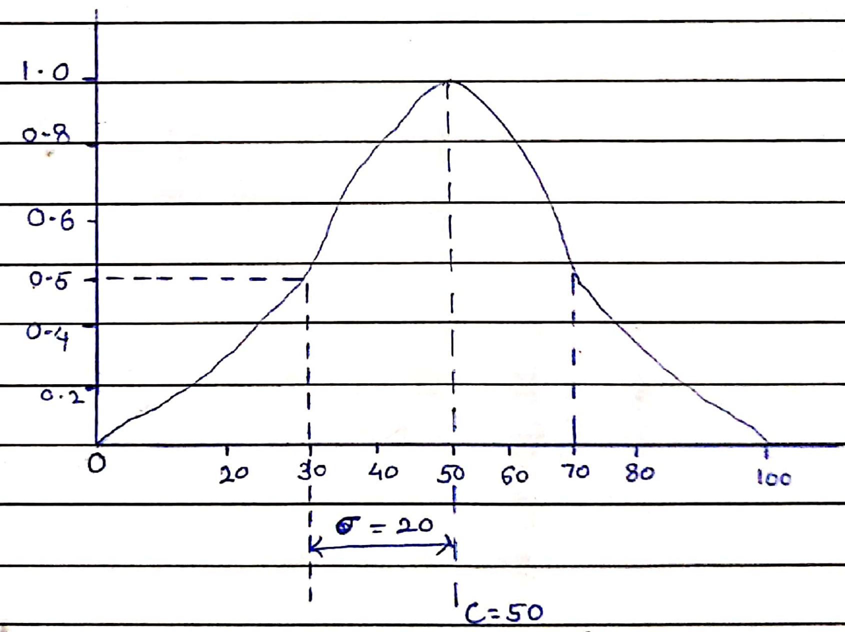
An alternative expression using min and max can be given as,

$$\mu_{trapezoid} = \max\left(\min\left(\frac{x-a}{b-a}, 1, \frac{d-x}{d-c}\right), 0\right)$$

(5) Gaussian MF:

- A Gaussian MF is specified by two parameters {c, σ}

$$\text{Gaussian}(x; c, \sigma) = e^{-1/2\left(\frac{x-c}{\sigma}\right)^2}$$



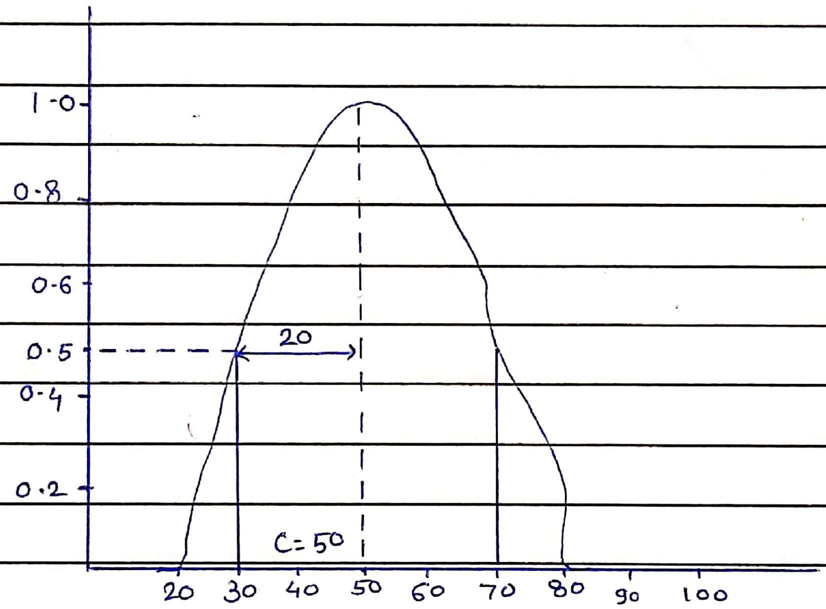
Gaussian (x; 50, 20) MF

- c represent MFs center
- σ determines MFs width.

⑥ Generalized Bell MF / Cauchy MF

- A Generalized Bell MF is specified by three parameters (a, b, c)

$$\text{bell}(x; a, b, c) = \frac{1}{1 + \left|\frac{x-c}{a}\right|^{2b}}$$



A desired generalized bell MF can be obtained by a proper selection of the parameters a, b, c.

- C specifies the center of Bell MF.
- a specifies the width of bell MF
- b determines the slope at the crossover points.

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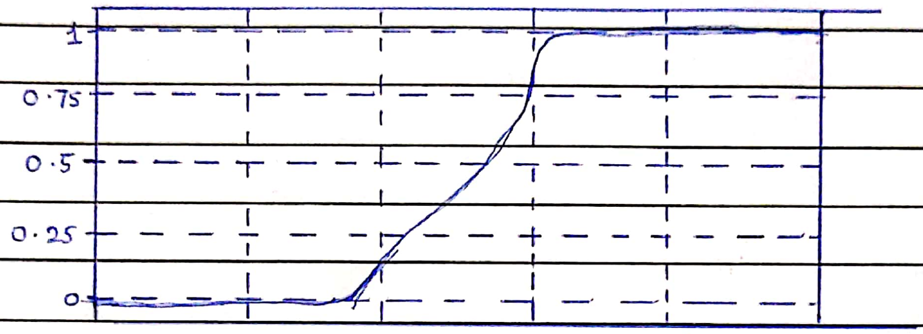
7. Sigmoidal MFs
- A sigmoidal MF is defined by

$$\mathrm{sigmf}(x; a, c) = \frac{1}{1 + e^{-a(x-c)}}$$



where, a controls the slope at the crossover point $x = c$

- Depending on the sign of the parameter a, a sigmoidal MF is open right or open left and thus is appropriate for representing concepts such as "Very large" or "Very Negative"
- They are widely used as the activation function in artificial neural network.

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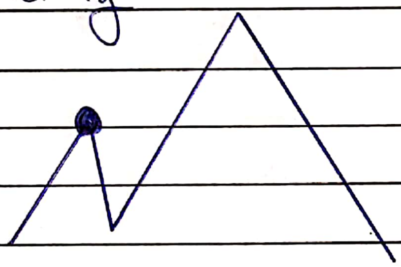
Q4 A] (iii)

Problems in Hill Climbing Technique

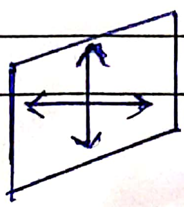
① Local Maxima

- Local Maxima is a state that is better than all of its neighbours.
- But it is not better than some states far away
- Hill Climbing Algorithm tends to find only local maxima
- This problem can be solved by using Backtracking



② Ridges

- Ridge is a curve in the search space that can lead to maxima.
- The orientation of the high region, compared to the set of available moves, makes it impossible to climb up.
- However, two moves executed serially may increase the height.
- Move to the several direction at once can help in dealing with the ridges.



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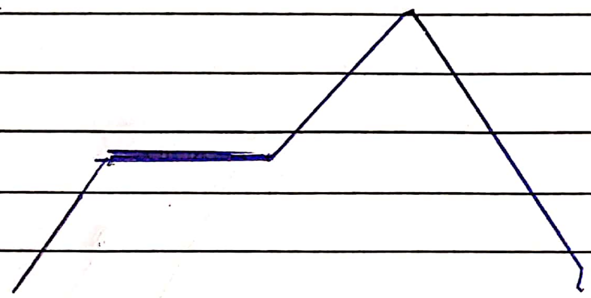
③ Plateau:

- Plateau is a flat area of the search space in which all neighbouring states have the same value.
- The heuristic of plateau region has same value
- In plateau it is not possible to determine the best direction by using local comparison
- Solution to plateau is to take a big jump to any direction to get to a new search space.



Amey.

Q4 B (i)

Chromosome

- In genetic algorithm, a chromosome is a set of parameters which define a proposed solution to the problem that the genetic algorithm is trying to solve.
- The set of all solutions is known as population

Fitness Function

- A fitness function is a particular type of objective function
- The fitness function is a function which takes a candidate solution to the problem as input and produces as output how "fit" our how "good" the solution is with respect to the problem in consideration.

Crossover

- Crossover is also known as recombination
- Crossover is a genetic operator used to combine the genetic information of two parents to generate new offspring.

Mutation

- Mutation is a genetic operator used to maintain genetic diversity from one generation of population of genetic algorithm chromosomes to the next.
- It is analogous to biological mutation.

Amey.