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Date
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AIDS Assignment - 1 (End Sem Special Exam)

Q1.) Explain operation of on fuzzy set.

Ans- Union - Consider 2 fuzzy sets denoted by A & B.
Let y be union of them. Therefore for every member of A & B
Y: degree_of_membership (Y) = max{degree_of_membership (A), degree_of_membership (B))

$$A = \{0.2/a + 0.3/b + 0.6/c + 0.6/d\}$$
$$B = \{0.9/a + 0.9/b + 0.4/b + 0.5/d\}$$
$$Y = \{0.9/a + 0.9/b + 0.6/c + 0.6/d\} = \bar{A} \cup \bar{B}$$

2.) Intersection
$$Y = \min(\mu_{(A)}(x), \mu_{(B)}(y))$$
Eg - $Y = \{0.2/a + 0.3/b + 0.4/c + 0.5/d\} = \bar{A} \cap \bar{B}$

3.) Complement
$$\mu(Y) = 1 = \mu(A)$$
Eg
$$A = \{0.8/a + 0.7/b + 0.4/c + 0.4/d\}$$
$$Y = \{1 - 0.8/a + 1 - 0.7/b + 1 - 0.4/c + 1 - 0.4/d\}$$
$$= \{0.2/a + 0.3/b + 0.6/c + 0.6/d$$

4.) Difference
$$\mu_{(Y)}(x) = \{\min(\mu_A(x), 1 - \mu_B(x))\}$$

$$A = \{0.2/a + 0.3/b + 0.6/c + 0.6/d\}$$
$$B = \{0.9/a + 0.9/b + 0.4/c + 0.5/d\}$$
$$Y = \min\{(0.2, 0.1), (0.3, 0.1), (0.6, 0.6), (0.6, 0.5)\}$$

$$\Rightarrow 0.1/a + 0.1/b + 0.6/c + 0.5/d$$

Teacher's Sign.:

Q2.) Representation of Knowledge in Cognitive System state.

Ans- 1.) Taxonomy

a.) Hierarchical structure - Taxonomies are heirarchical framework structures that ~~to~~ organises concepts into category and subcategory and present knowledge in structured manner.

b.) Capture membership and subdomain relation & therefore must be complete, consistent and unambiguous.

c.) At any level in taxonomy, no common elements between classes if any, a new, common higher level category is required.

d.) Members inherit properties of ancestors (inheritance).

e.) Rules and constructs doesn't change over time (OOPS).

2.) Ontology.

a.) Representation of relations between concepts all over domain of ~~discoverage~~ discourse. Organise concepts and decrease complexity.

b.) More difficult to construct than taxonomy.

c.) Simple tree - Child parent relationship Eg- Catelog.

d.) Semantic Web → Eg www, content, SRL.

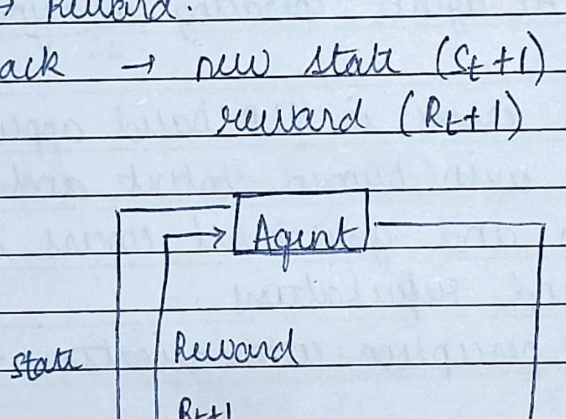
Q3.) Explain MDP in detail.

Ans- 1.) It is a stochastic decision making Process that uses mathematical framework to model dynamic systems controlled by a decission maker, which makes sequential decision over time.

2.) Relies on environment, agent action, rewards for optimal ans actions. 4 categories - finite, infinite, continuous discrete.

Teacher's Sign.: ____________

3.) Works on probabilistic dynamics.
4.) Works in probabilistic planning and reinforcement learning
5.) States $(s \in S)$
Action $(a \in A)$
$P(S_{t+1} / S_t, a_t) \rightarrow$ Transition Probability.
$R(S) \rightarrow$ Reward.
6.) Feedback (RL) $\rightarrow$ new state $(S_t + 1)$
reward $(R_t + 1)$



$$P(S_{t+1} / S_t) = P(S_{t+1} / S_1, S_2, S_3 \cdots S_t)$$

- AIDS End Sem Paper - 1

Q4) What is uncertainity in AI. Explain its different sources.

Ans) AI uncertainity is when there's not enough information or ambiguity in data or decision making. The retal world data is often noisy and incomplete. AI systems must account for uncertainity to make informed decisions.

1) Data uncertainity - AI models are trained on noisy data so uncertain predictions.
2) Model uncertainity - AI models are complex and have various parameters and hyperparameters tuned, effecting impact on result.
3) Algorithmic - AI models based on different mathematical computations and ML algo.
4) Environmental - AI agents operating in dynamic environment.
5) Human - Human errors in NLP based applications misunderstanding with human context and adoption.
6) Ethical - Human and government concers and privacy.
7) Legal - Laws and regulations.
8) AI reasoning, perception communication.

Q5) Explain cognitive computing and its working.

Ans 1) Cognitive computing is an attempt to have computer mimic the way human brain works with the use of AI and underlying technologies by training, testing and scoring a data hypothesis.
2) Using neural networks ML, DL, NLP, speech recognition OpenCV, OCR etc. to make computerised models simulate human complex thoughts.
3) Learn - Make inference from domain based on topic, person, data and observation from big data.
4) Model - Create a model representation of domain and assumption (ML).
5) Generate hypothesis - Appropriate answer is based on data itself, there is no single correct answer.

Teacher's Sign.:

Features - Adaptive + Interactive + Iterative + Stateful + Contextual.

Q6) Bayes Question

$P(s/m) = 0.5$

$P(m) = 1/50,000$

$P(s) = \frac{1}{20}$

S → Stiff neck

m → have meningitis.

$\therefore P(m/s) = \frac{P(s/m) \cdot P(m)}{P(s)}$

$\Rightarrow \frac{0.5 \times 1 \times 20}{50000} \Rightarrow 0.0002$

Q7) Maximin composition.

$\tilde{P} = \frac{0.1}{c_1} + \frac{0.5}{c_2} + \frac{1.0}{c_3}$

$\tilde{S} = \frac{0.3}{s_1} + \frac{0.8}{s_2}$

Cartesian product $(\tilde{R} = \tilde{P} \times \tilde{S})$

$$\tilde{R} = \begin{bmatrix} \min(0.1, 0.3) & \min(0.1, 0.8) \\ \min(0.5, 0.3) & \min(0.5, 0.8) \\ \min(1.0, 0.3) & \min(1.0, 0.8) \end{bmatrix}$$

$$= \begin{bmatrix} 0.1 & 0.1 \\ 0.3 & 0.5 \\ 0.3 & 0.8 \end{bmatrix}_{3\times 2}$$

$$\tilde{P} = \frac{0.4}{c_1} + \frac{0.7}{c_2} + \frac{1.0}{c_3}$$

Using max-min composition

$$\tilde{S} = \tilde{P} \circ \tilde{R}$$

Using $\mu_{\tilde{S}*}(S_j) = \max(\min(\mu_{\tilde{P}*}(c_i), \mu_{\tilde{R}}(c_i, S_j)))$.

$\therefore S_1 \rightarrow \max(\min(0.4, 0.1), \min(0.7, 0.3), \min(1, 0.3))$

$\Rightarrow \max(0.1, 0.3, 0.3) \Rightarrow \underline{0.3}$

$S_2 \rightarrow \max(\min(0.4, 0.1), \min(0.7, 0.5), \min(1.0, 0.8))$

$\Rightarrow \max(0.1, 0.5, 0.8) \Rightarrow \underline{0.8}$

$\tilde{S}* = \frac{0.3}{S_1} + \frac{0.8}{S_2}$ (a new fuzzy set).

Q8.) ~~Bayesian network~~ Explain bayesian network, its structure semantics and applications?

Ans - 1.) A bayesian network is a probabilistic graphical model which represents a set of variables and their conditional dependencies using a DAG.

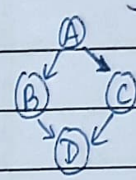
2.) They are probabilistic and uses bayes theorem and has 2 parts :- DAG and Conditional Probablity Table.

4) A bayesian network under certain knowledge is called influence diagram. A node represents random variable, directed arrows, relationship or conditional probabilities.

5) It cant be cyclic in nature

6) To understand network as representation of Joint Probability Distribution.

7.) To understand network as encoding of conditional independence statements.



8.) Graphical structure — Probabilistic Influence.
conditional independence node — Evidential reasoning
parameters. — Learning from data.

9.) Applications — medicine, finance, genetics & AI, ~~health~~ healthcare etc.

Q9.) Steps to build cognitive application in healthcare.

Ans - 1.) Define the objective → State clearly the problem to be solved Eg - Improve the diagnostic accuracy, personalise treatment plans.

2.) Define domain → Identify specific area (oncology, cardio-logy). therefore narrowing down scope and relevent knowledge source.

3.) Identify intended user - attributes → who will use the application (doctor, nurse, patient) their needs, experience, workflow etc. For effective UI and adoption.

4.) Define questions and exploring insights - To achieve objectives and exploring potential insights and that application provide data.

5.) Acquire relevent data sources - Eg EHR, Xray, MRI genomic data, prescriptions etc. Data privacy and security is important.

6.) Create and refine corpora - Prepare and structure acquired data into usable format for cognitive system Eg - extract information from X-ray images, prescription.

7.) Training and testing - Using Machine learning, Natural Language Processing, rigourusly and evaluate on unseen data for iterative refinement.

Q10.) Using Mamdani Fuzzy model design frequency logic control to feed amount of water purifier for the water purification plant. Assume input as water temperature and grade of water. Use 3 descriptors for both input and output variables. Derive necessary membership function and required fuzzy rules for both the input and output variables ~~for~~ for the application. From the rule base, validate a rule base by considering a suitable example.

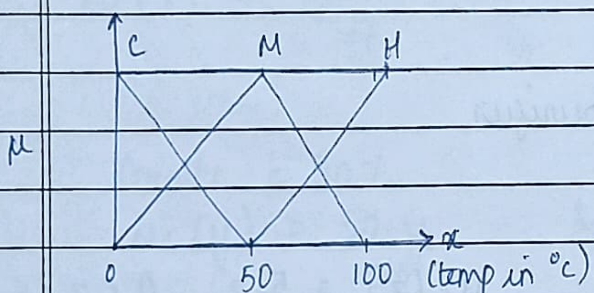
Ans- 1.) Identify input and output variables

Input → Water temperature
- Cold (C)
- Medium (M)
- High (H)

Grade
- Low (L)
- Medium (M)
- High (H)

Output → Amount of purifier
Small (S)
Medium (M)
Large (L)

a.) Membership functions



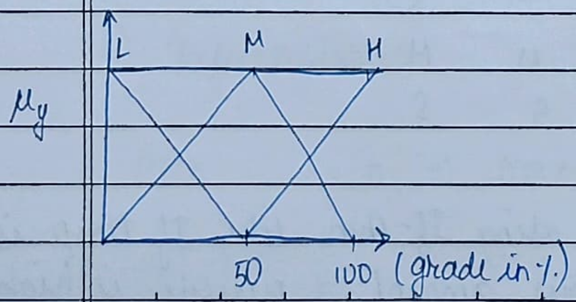
$\mu_C(x) = \frac{50-x}{50}, \quad 0 \le x \le 50$

$\mu_M(x) = \frac{x}{50}, \quad 0 \le x \le 50$

$\frac{100-x}{50}, \quad 50 \le x \le 100$

$\mu_H(x) = \frac{x-50}{50}, \quad 50 \le x \le 100$

b.) Membership func for grade of water.

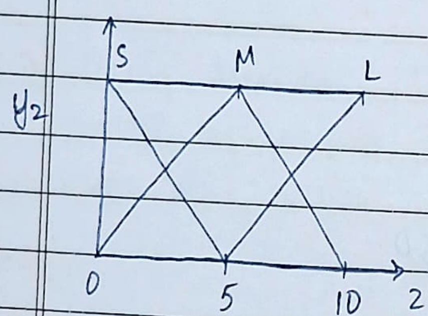


$\mu_L(y) = \frac{50-y}{50} \quad 0 \le y \le 50$

$$\mu_M(y) = \begin{cases} \frac{y}{50} & 0 \leq y \leq 50 \\ \frac{100-y}{50} & 50 \leq y \leq 100 \end{cases}$$

$$\mu_H(y) = \frac{y-50}{50}, \quad 50 \leq y \leq 100$$

c) MF for amount of purifier



$$\mu_S(z) = \frac{5-z}{5}, \quad 0 \leq z \leq 5$$

$$\mu_M(z) = \begin{cases} \frac{z}{5} & 0 \leq z \leq 5 \\ \frac{10-z}{5}, & 5 \leq z \leq 10 \end{cases}$$

$$\mu_L(z) = \frac{z-5}{5}, \quad 5 \leq z \leq 10$$

3.) Form a rule base

Temp of water	L	H	H
C	L	M	S
M	L	M	M
H	M	S	S

These rules are defined using If-then like If temp is low & grade of water is low amount of purifier is high.

4.) Rule evaluation

Assume water temp $= 5^{\circ}C$ & grade of water $= 30\%$.

Water temp $= 5^{\circ}C$

$\mu_C(x) = \frac{50-x}{50}$ & $\mu_M(x) = \frac{x}{50}$

$\mu_C(5) = \frac{50-5}{50} \Rightarrow \frac{9}{10}$ $\mu_M(5) = \frac{5}{50} \Rightarrow \frac{1}{10}$

Grade $= 30\%$.

$\mu_L(y) = \frac{50-y}{50}$ & $\mu_M(y) = \frac{y}{50}$

$\mu_L(30) \Rightarrow \frac{50-30}{50}$ $\mu_M(y) = \frac{3}{5}$

$\Rightarrow \frac{2}{5}$

Strength of rule 1 : $S_1 = \min\left(\frac{9}{10}, \frac{2}{5}\right) = \frac{2}{5}$

Strength of rule 2 : $S_2 = \min\left(\frac{9}{10}, \frac{3}{5}\right) \Rightarrow \frac{3}{5}$

Strength of rule 3 : $S_3 = \min\left(\frac{1}{10}, \frac{2}{5}\right) \Rightarrow \frac{1}{10}$

Strength of rule 4 : $S_4 = \min\left(\frac{1}{10}, \frac{3}{5}\right) \Rightarrow \frac{1}{10}$

5.) Defuzzification.

max strength $\Rightarrow \max\left(\frac{2}{5}, \frac{3}{5}, \frac{1}{10}, \frac{1}{10}\right) \Rightarrow \frac{3}{5}$

$\therefore$ rule 2

$\therefore$ 2 eqns $\mu_M(z) = \frac{z}{5}$ & $\mu_M(z) = \frac{10-z}{5}$

Strength of rule is $\frac{3}{5}$.

$\therefore \mu_M(z) \Rightarrow \frac{3}{\cancel{5}} = \frac{z}{\cancel{5}}$ $\therefore \boxed{z=3}$

$\mu_M(z) \Rightarrow \frac{10-z}{\cancel{5}} = \frac{3}{\cancel{5}}$

$\boxed{z=7}$

$\therefore$ Avg $z^* = \frac{7+3}{2} \Rightarrow 5$ gm

- Paper - 3

Q11.) Explain the hidden Markov decision process with suitable example.

Ans- A Hidden Markov Decision Process (HMDP) is a decision making model where the true state of system is hidden. It extends the MDP by adding hidden states and observable outputs. In the HMDP the agent does not directly see the states but gets observation that gets clues about it. the agent uses the observations to update its belief about hidden state. Actions are then chosen based on this belief to maximise long term rewards. This process involves states, actions, observations, transition probabilities and rewards. It is useful for uncertain and partially observable environments. For example a robot cleaning a house cannot directly know if a room is ~~dirt~~ dirty. It uses noise sensor readings (observations) to estimate cleanliness (hidden state). Then it decides whether to clean, move aiming for maximum efficiency.

Q12) P(cold & considering malaria as evidence) = P(cold/malaria)

= $\frac{P(\text{cold and malaria})}{P(\text{malaria})}$ = $\frac{P(\text{cold \& catch \& malaria}) + P(\text{cold \& no catch + malaria})}{P(\text{cold \& cat \& mal}) + P(\text{cold \& no cat \& no mal}) + P(\text{no cold \& catch \& mal}) + P(\text{no cold + no cat})}$

$\Rightarrow$ ~~P(0.1~~ $\frac{0.133 + 0.034}{0.133 + 0.034 + 0.030 + 0.065}$ $\Rightarrow \frac{0.167}{0.262} \simeq 0.6374$

$\Rightarrow$ 63.74%.

Q13) What is the role of NLP in Cognitive System?

Ans- To role of NLP in cognitive system is to enable machines to understand, interpret and respond to human language in natural way. NLP helps cognitive system process unstructured text and speech and extract meaning and convert it into structured info that machines can work with. It allows systems to understand context, sentiments and intent behind human communication. Through NLP, CS can engage in conversations, answer questions, translate language, summarise documents and analyse large volumes of text data. This makes human computer interaction. For example chatbots, virtual assistant and recommendation systems rely heavily on NLP to interact intelligently with users. Thus NLP acts as a bridge between human communication and machine intelligence in cognitive computing.

Q14.) What is uncertainity in AI? Explain bayesian belief network with examples.

Ans- Uncertainity in AI refers to situations where systems work with incomplete, noisy or ambiguous data, making it hard to predict outcomes with full confidence. Handling uncertainity is important because most real world are dynamic and unpredictable. To address this AI uses models like Bayesian Belief Network (BBN) which is probabilistic graphical model representing variables and nodes and their dependencies as directed edges. Each node is assigned a conditional probabilistic values showing how it depends on others and Baye's theorem is applied to update belief when new evidence is observed. For example in medical dignostic a disease like Flu may lead to symptoms such as fever & cough. If a person shows these symptoms, the BN calculates probabily the patient has flu. This helps doctor make better decisions based on evidence. This way, BBN allows AI systems to reason, predict and take actions effectively under uncertainity.

Q15) $\tilde{A} = \begin{bmatrix} 0.0 & 0.2 & 0.8 \\ 0.3 & 0.6 & 1.0 \end{bmatrix}_{x \times y}$ $\tilde{B} = \begin{bmatrix} 0.3 & 0.7 & 1.0 \\ 0.5 & 1.0 & 0.6 \\ 1.0 & 0.2 & 0.0 \end{bmatrix}_{y \times z}$

Max-min composition

$\mu(x_1, z_1) = \max(\min(0, 0.3), \min(0.2, 0.5), \min(0.8, 1.0)) \Rightarrow 0.8$
$\mu(x_1, z_2) = \max(\min(0, 0.7), \min(0.2, 1), \min(0.8, 0.7)) \Rightarrow 0.2$
$\mu(x_1, z_3) = \max(\min(0, 0.3), \min(0.2, 0.6), \min(0.8, 0)) \Rightarrow 0.2$
$\mu(x_2, z_1) = \max(\min(0.3, 0.3), \min(0.6, 0.5), \min(1.0, 1.0)) \Rightarrow 1$
$\mu(x_2, z_2) = \max(\min(0.3, 0.7), \min(0.6, 1), \min(1, 0.2)) \Rightarrow 0.6$
$\mu(x_2, z_3) = \max(\min(0.3, 1.0), \min(0.6, 0.0), \min(1.0, 0)) \Rightarrow 0.6$

$\therefore T = \begin{bmatrix} 0.8 & 0.2 & 0.2 \\ 1.0 & 0.6 & 0.6 \end{bmatrix}$

Max product composition.

$\mu(x_1, z_1) = \max(0, 0.1, 0.8) = 0.8$
$\mu(x_1, z_2) = \max(0, 0.2, 0.16) = 0.2$
$\mu(x_1, z_3) = \max(0, 0.12, 0) = 0.12$
$\mu(x_2, z_1) = \max(0.09, 0.3, 1.0) = 1$
$\mu(x_2, z_2) = \max(0.21, 0.6, 0.2) = 0.6$
$\mu(x_2, z_3) = \max(0.3, 0.36, 0) = 0.36$

$$\therefore T = \begin{bmatrix} 0.8 & 0.2 & 0.12 \\ 1.0 & 0.6 & 0.36 \end{bmatrix}$$

Q16.) Consider a water heater which outputs hot water with respect to rotation of the valve. Design a fuzzy control system for a water heater. Assume the inputs & outputs and descriptor. Form a rule base, Validate a rule base by considering a suitable example.

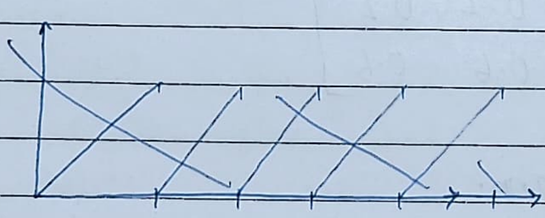
Ans- 1.) Identify input & output descriptors.

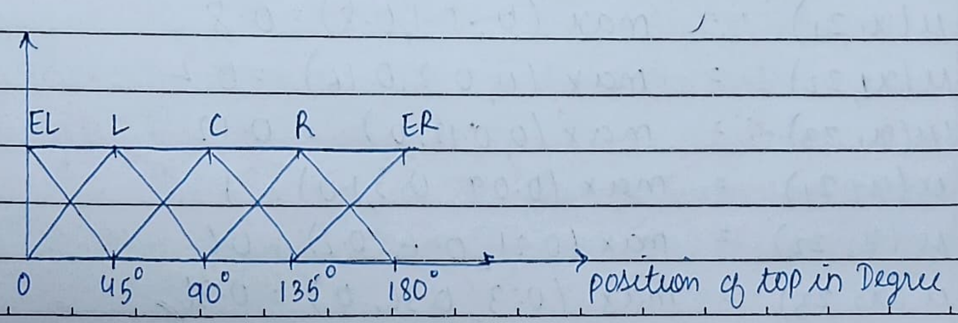
For a position of valve ⇒ Extreme Left (EL), Left (L), Center (C), Right (R), Extreme Right (ER).

For temperature ⇒ Very Cold (VC), Cold (C), Medium (M) Hot (H), Very Hot (VH).

2.) Membership Functions

a.) MF for position of valve.





$\mu_{EL}(x) = \frac{45-x}{45}, \quad 0 \le x \le 45$

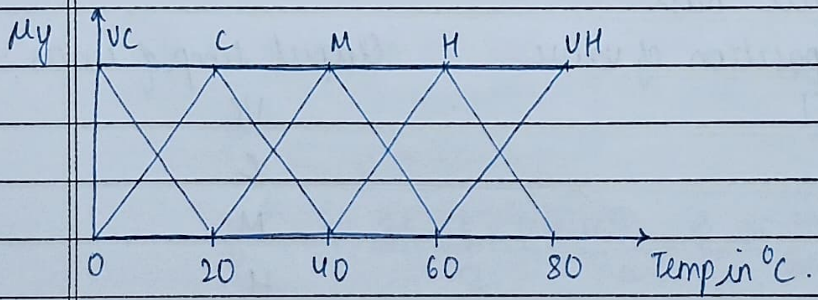
$$\mu_L(x) = \begin{cases} \frac{x}{45}, & 0 \le x \le 45 \\ \frac{90-x}{45}, & 45 \le x \le 90 \end{cases}$$

$$\mu_C(x) = \begin{cases} \frac{x-45}{45}, & 45 \le x \le 90 \\ \frac{135-x}{45}, & 90 \le x \le 135 \end{cases}$$

$$\mu_R(x) = \begin{cases} \frac{x-90}{45}, & 90 \le x \le 135 \\ \frac{180-x}{45}, & 135 \le x \le 180 \end{cases}$$

$\mu_{ER}(x) = \frac{x-135}{45}, \quad 135 \le x \le 180$

b.) MF for temperature



$\mu_{VC}(y) = \frac{20-y}{20}, \quad 0 \le y \le 20$

~~$\mu_M(y) = \frac{y-20}{20}$~~

$$\mu_M(y) = \begin{cases} \frac{y-20}{20}, & 20 \le y \le 40 \\ \frac{60-y}{20}, & 40 \le y \le 60 \end{cases}$$

$\mu_{VH}(y) = \frac{y-60}{20}, \quad 60 \le y \le 80$

$$\mu_C(y) = \begin{cases} \frac{y}{20}, & 0 \le y \le 20 \\ \frac{40-y}{20}, & 20 \le y \le 40 \end{cases}$$

$$\mu_H(y) = \begin{cases} \frac{y-40}{20}, & 40 \le y \le 60 \\ \frac{80-y}{20}, & 60 \le y \le 80 \end{cases}$$

3.) Form a rule base

Input position of value	Output temp of water.
EL	VC
L	C
C	M
R	H
ER	V.H.

4.) Rule Evaluation

Assume position of value → 80°.

80° maps to 2 MF.

$\mu_L(x) = \frac{90-x}{45}$ & $\mu_C(x) = \frac{x-45}{45}$

$\mu_L(80) \Rightarrow \frac{90-80}{45}$ & $\mu_C(80) \Rightarrow \frac{80-45}{45}$

$\Rightarrow \frac{2}{9}$ $\Rightarrow \frac{7}{9}$

5.) Defuzzification

We use mean of max.

$\text{Max}(\mu_L(x), \mu_C(x)) = \max\left(\frac{2}{9}, \frac{7}{9}\right) \Rightarrow \frac{7}{9}$

This corresponds to rule 3.

The strength of rule base is :- $\frac{7}{9}$

$\mu_M(y) = \frac{y-20}{20}$ & $\mu_M(y) = \frac{60-y}{20}$

$\frac{7}{9} = \frac{y-20}{20}$

$140 = 9y - 180$

$\therefore y = \frac{180+140}{9}$

$y = \frac{320}{9} \Rightarrow \underline{\underline{35.55}}$

$\frac{7}{9} = \frac{60-y}{20}$

$540 - 9y = 140$

$\therefore y = \frac{540-140}{9}$

$y = \frac{400}{9} \Rightarrow \underline{\underline{44.44}}$

$\therefore y^* = \frac{35.55+44.44}{2} \Rightarrow \simeq \underline{\underline{40°C}}$

Q17) What are the design principles of cognitive System?

Ans- a.) Identify - Identify the lowest level problems.

b.) Define - Define bigger business problems.

c.) Brainstorm - List down various knowledge sources and questions to fed that could be fed.

d.) Prototype - Develop a system and train it to provide insights with high confidence level.

e.) Implement - Implement it ~~to~~ live to gain more training and knowledge.

f.) Evaluate - Get system evaluated in live and improve with feedback.

g.) Ensure - Ensure system evolves overtime and evolves over time.