

Ques. 1.) Draw and explain Markov decision process.

Ans.

- The markov decision process is model of predicting outcomes.
- Markov Decision process is mathematical framework to describe on enviorment reinforcement learning component of MDP:-



1. Agent :- An agent is entity which are trained to make correct decision.
 2. Enviornment :- The enviornment is surrounding with which agent can interact.
 3. state :- The state defines current situation.
 4. Action :- The choice that agent makes.
 5. Reward :- A reward is thought process behind picking up every action. High rewarding action will've high probability and vice versa.
- In MDP, we have decision maker, called agent that interacts with enviornment it's placed in.
 - These interaction occurs sequentially overtime. At each time step, agent will get some representation of enviornment state, Given this representation is then transitioned to new state, and agent is given a reward as consequence of previous action.

Que. 2) Ans.

Let A, B, C be events of choosing the boxes A, B and C respectively.

Let X be event of drawing red ball from chosen box ;
since boxes are identical

$$P(A) = P(B) = P(C) = \frac{1}{3}.$$

We have to find $P(A_i | X)$

By given problem,

$$P(X|A) = \frac{2}{2+3} = \frac{2}{5}$$

$$P(X|B) = \frac{3}{3+1} = \frac{3}{4}$$

$$P(X|C) = \frac{1}{1+4} = \frac{1}{5}$$

Hence by using Baye's Theorem;

$$\begin{aligned} P(A|X) &= \frac{P(A) P(X|A)}{P(A) P(X|A) + P(B) P(X|B) + P(C) P(X|C)} \\ &= \frac{\left(\frac{1}{3}\right)\left(\frac{2}{5}\right)}{\left(\frac{1}{3}\right)\left(\frac{2}{5}\right) + \left(\frac{1}{3}\right)\left(\frac{3}{4}\right) + \left(\frac{1}{3}\right)\left(\frac{1}{5}\right)} \end{aligned}$$

$$\boxed{P(A|X) = \frac{8}{21}}$$



Ques 3) What is cognitive computing? Explain Advantages and Disadvantages.

Ans:

- cognitive computing is use of computerized model to stimulate the human thought process in complex situations where the answers maybe ambiguous and uncertain.
- computer are faster than human at processing and calculating about they are yet to mastersome task such as understanding natural language and recognizing objects in an image.
- computing is an attempt to have computers mimic the way human brain works.
- cognitive computing uses there process in conjunction with self learning algorithm, data analysis and patter recognition to teach system.
- siri, Alexa, cortona are few examples.
- cognitive computing works on following principles

① learn -

- A cognitive computing can learn.

- Based on training & observation from all types of data / information.

② Model -

- Inorder for system to learn ,it must first construct a model or representation of domain.

③ General Hypothesis -

There is no single proper solution according to cognitive system. The best response is determined by data.

Advantages :-

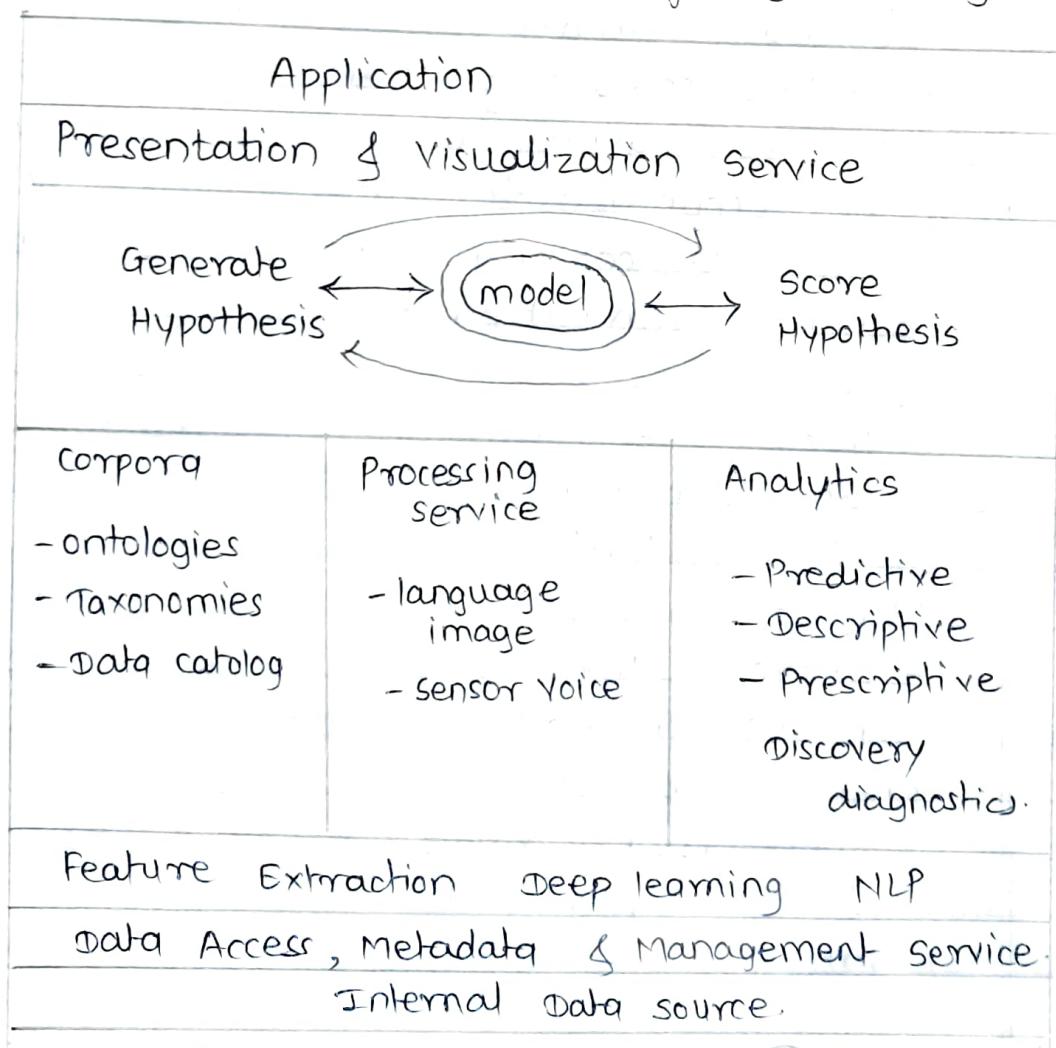
- 1) Business process efficiency
- 2) Analytical survey.
- 3) Consumer interaction & experience.
- 4) Employee productivity & service quantity
- 5)

Disadvantages :-

- 1) Security challenges.
- 2) Negative environment impact.
- 3) Long development cycle length and slow adoption.

Ques. 4.) Sketch and explain Architecture of cognitive system.

Ans.





A cognitive system is made up of several components ranging from hardware and deployment model to machine learning & Application. The following an overview of architecture of cognitive system

(1) Infrastructure and deployment Modalities :-

- It is important in cognitive system to have flexible & agile infrastructure
- A wide range of public & private data must be maintained and processed at market for cognitive technologies grow.

(2) Data Access, Metadata and Management services

- There is variety of internal and external data source that will be included in corpus.
- Data procurement, access and management play vital role.

(3) The corpus, Taxonomies and Data catalogs

- The corpus and data Analytics services and tightly anoted with data access and management layer.
- A corpus is repository of data that is used to manage codified knowledge. The corpus contains the information necessary to establish domain.

(4) Data Analytics services .

- Incorporating data analytics into corpus involved techniques for gaining deeper understanding of it
- By using structured, unstructured or semi-structured data that has been ingested, user can begin to predict outcome, discover pattern and determine next best action.

(5) Continuous Machine Learning :-

- Machine learning is method of data to learn without having to be actively programmed.
- 2 fundamental components are hypothesis generation and hypothesis evaluation.

(6) Tools and the learning process

- NLP services can evaluate and find patterns in unstructured textual input to help a cognitive system.
- Deep learning tools are required for unstructured data such as photos, audio and videos.

(7) Presentation and Visualization Technique.

- Data visualization is visual representation of data as well as the visual analysis of data.
- A bar chart or pie chart is visualization of underlying data.
- Static and dynamic data visualizations are the two fundamental forms.

(8) Cognitive Applications :-

To allow development of application may need to incorporate procedure to acquire insight into complex business. (ex. healthcare, logistics etc.)



Ques 5) Explain the role of NLP in cognitive system.

Ans.

- cognitive computing is technology that helps in mimicing the human thought process.
- NLP plays a vital role in building cognitive system as natural language understanding and natural language generation have been inevitable human feature.
- NLP is core ability of cognitive computing system and often defined as helping compress.
- NLP enables computers to understand language, the components are parts of speech tagging named entity resolution, word sense disambiguation and conference resolution.
- NLP include machine learning techniques, computational linguistic & statics across training corpora
- NLP and cognitive computing rely on each other NLP aids cognitive computing and viceversa.
- NLP itself can be seen as cognitive technology because it uses sensory perception.

Ques 6) Explain the Seven steps of building a cognitive application.

Ans.

(i) Defining the objective:-

- i) The first step in development is understanding the type of problem cognitive application will solve
- ii) Objective should take into consideration types of users one will be appealing to, whether user will be from different communities what issue users are rarely interested in.

(2) Defining the domain:-

- i) Next step is to determine the domain or subject area for the cognitive application.
- (a) Domain : Medicine ; data source : Electronic

(3) Understanding the intended users and their attributes:-

- i) Expectation for user and system interactions will influence the corpus , creation , the user . Interface's design and how system is trained .
- ii) Degree of precision is determined .

(4) Defining and exploring insights :-

- i) A cognitive system generates and score hypothesis to answer questions or provide insights .
- ii) When designing , one should start by mapping out type of questions user may ask .

(5) Acquiring Relevant data source:-

It enable use of data source in new direction .

- a) Internal data b) Dark data c) External data .

(6) Creating and refining the corpora:-

Process of creating corpora of data includes .

- (1) Preparing the data (2) Ingesting the data
- (3) Refining and Expanding the corpora
- (4) Governance of Data .

(7) Training and Testing:-

Training and testing can ensure that yours application works as intended when it becomes optional .



Que. 7.)

$$X = \left\{ \frac{0.2}{1} + \frac{0.3}{2} + \frac{0.4}{3} + \frac{0.5}{4} \right\}$$

$$Y = \left\{ \frac{0.1}{1} + \frac{0.2}{2} + \frac{0.2}{3} + \frac{0.1}{4} \right\}$$

Perform : a) Union b) Algebraic sum c) Algebraic product
d) Bounded sum e) Bounded difference f) Intersection g) complement of X and Y .

Ans.

a) Union

$$\begin{aligned} X \cup Y &= \max \{ u_X(x), u_Y(x) \} \\ &= \left\{ \frac{0.2}{1} + \frac{0.3}{2} + \frac{0.4}{3} + \frac{0.5}{4} \right\} \end{aligned}$$

b) Algebraic sum

$$u_{X+Y}(x) = u_X(x) + u_Y(x) - [u_X(x) \cdot u_Y(x)]$$

Now,

$$u_X(x) \cdot u_Y(x) = \left\{ \frac{0.02}{1} + \frac{0.06}{2} + \frac{0.08}{3} + \frac{0.05}{4} \right\} \quad \textcircled{1}$$

$$\text{Hence, } u_{X+Y}(x) = \left\{ \frac{0.2+0.1-0.02}{1} + \frac{0.5-0.06}{2} + \frac{0.6-0.08}{3} + \frac{0.55}{4} \right\}$$

$$\therefore u_{X+Y}(x) = \left\{ \frac{0.28}{1} + \frac{0.44}{2} + \frac{0.52}{3} + \frac{0.55}{4} \right\}$$

c) Algebraic Product

$$\begin{aligned} u_{X \cdot Y}(x) &= u_X(x) \cdot u_Y(x) \\ &= \left\{ \frac{0.02}{1} + \frac{0.06}{2} + \frac{0.08}{3} + \frac{0.05}{4} \right\} \end{aligned}$$

d) Bounded sum

$$= \min \{ 1, u_X(x) + u_Y(x) \}$$

$$= \min \{ 1, \left\{ \frac{0.3}{1} + \frac{0.5}{2} + \frac{0.6}{3} + \frac{0.5}{4} \right\} \}$$

$$= \left\{ \frac{0.3}{1} + \frac{0.5}{2} + \frac{0.6}{3} + \frac{0.5}{4} \right\}$$

e) Bounded Difference

$$\begin{aligned} &= \max \{ 0, (\underline{\mu}_X(x) - \underline{\mu}_Y(x)) \} \\ &= \max \{ 0, \left\{ \frac{0.1}{1} + \frac{0.1}{2} + \frac{0.2}{3} + \frac{0.5}{4} \right\} \} \\ &= \left\{ \frac{0.1}{1} + \frac{0.1}{2} + \frac{0.2}{3} + \frac{0.5}{4} \right\} \end{aligned}$$

f) Intersection

$$\begin{aligned} \underline{x \cap y} &= \min \{ \underline{\mu}_X(x), \underline{\mu}_Y(x) \} \\ &= \left\{ \frac{0.1}{1} + \frac{0.2}{2} + \frac{0.2}{3} + \frac{0.5}{4} \right\} \end{aligned}$$

g) Complement of x and y

$$\overline{\underline{x}} = 1 - \underline{\mu}_X(x) = \left\{ \frac{0.8}{1} + \frac{0.7}{2} + \frac{0.6}{3} + \frac{0.5}{4} \right\}$$

$$\overline{\underline{y}} = 1 - \underline{\mu}_Y(x) = \left\{ \frac{0.9}{1} + \frac{0.8}{2} + \frac{0.8}{3} + \frac{0}{4} \right\}$$



Que. 8)

$$\tilde{A} = \left\{ \frac{1}{\text{Low}} + \frac{0.2}{\text{Medium}} + \frac{0.5}{\text{High}} \right\}$$

$$\tilde{B} = \left\{ \frac{0.9}{\text{Positive}} + \frac{0.4}{\text{zero}} + \frac{0.9}{\text{negative}} \right\}$$

$$\tilde{C} = \left\{ \frac{0.1}{\text{Low}} + \frac{0.2}{\text{medium}} + \frac{0.7}{\text{high}} \right\}$$

To find :- a) $R = \underline{\tilde{A}} \times \underline{\tilde{B}}$

$$b) S = \underline{\tilde{C}} \times \underline{\tilde{B}}$$

c) find max min composition $\underline{\tilde{C}} \circ \underline{\tilde{R}}$

d) find max min composition $\underline{\tilde{C}} \circ \underline{\tilde{S}}$.

Ans. a) $\mu_R(x, y) = \underline{\mu_{A \times B}}(x, y) = \min(\underline{\mu_A}(x), \underline{\mu_B}(y))$.

$$R = \begin{matrix} & & \\ x_1 & \begin{bmatrix} 0.9 & 0.4 & 0.9 \\ 0.2 & 0.2 & 0.2 \\ 0.5 & 0.4 & 0.5 \end{bmatrix} \\ x_2 & \\ x_3 & \end{matrix}, \quad \underline{\tilde{C}} = [0.1 \ 0.2 \ 0.1]_{1 \times 3}$$

b) $S = \underline{\tilde{C}} \times \underline{\tilde{B}}$

$$\mu_S(x, y) = \underline{\mu_{C \times B}}(x, y) = \min(\underline{\mu_C}(x), \underline{\mu_B}(y))$$

$$S = \begin{bmatrix} 0.1 & 0.1 & 0.1 \\ 0.2 & 0.2 & 0.2 \\ 0.7 & 0.4 & 0.7 \end{bmatrix}, \quad \underline{\tilde{C}} = [0.1 \ 0.2 \ 0.7]_{1 \times 3}$$

$$T = \underline{\tilde{C}} \circ \underline{\tilde{R}}$$

$$\mu_T(x, z) = \max(\min(\underline{\mu_C}(x, y), \underline{\mu_R}(y, z)))$$

$$\begin{aligned} \mu_T(x_1, z_1) &= \max(\min(0.1, 0.9), \min(0.2, 0.9), \min(0.7, 0.5)) \\ &= \max(0.1, 0.2, 0.5) \\ &= 0.5 \end{aligned}$$

$$\begin{aligned}\mu_T(x_2, z_2) &= \max(\min(\mu_C(x, y), \mu_R(x_2, z_2))) \\ &= \max(0.1, 0.2, 0.4) \\ &= 0.4.\end{aligned}$$

$$\begin{aligned}\mu_T(x_3, z_3) &= \max(0.1, 0.2, 0.5) \\ &= 0.5.\end{aligned}$$

$$T = [0.5 \ 0.4 \ 0.5]_{1 \times 3}$$

(d) max min composition of $C \circ S$

$$C = [0.1 \ 0.2 \ 0.7] \quad S = \begin{bmatrix} 0.1 & 0.1 & 0.1 \\ 0.2 & 0.2 & 0.2 \\ 0.7 & 0.4 & 0.7 \end{bmatrix}$$

$$P = C \circ S$$

$$\mu_P(x, z) = \max(\min(\mu_C(x, y), \mu_S(y, z)))$$

$$\begin{aligned}\mu_P(x_1, z_1) &= \max(0.1, 0.2, 0.7) \\ &= 0.7\end{aligned}$$

$$\begin{aligned}\mu_P(x_2, z_2) &= \max(0.1, 0.2, 0.4) \\ &= 0.4\end{aligned}$$

$$\begin{aligned}\mu_P(x_3, z_3) &= \max(0.1, 0.2, 0.7) \\ &= 0.7\end{aligned}$$

$$P = [0.7 \ 0.4 \ 0.7]_{1 \times 3}$$



Que. 9.)

Describe all methods of defuzzification in detail with example of lambda cut and centroid.

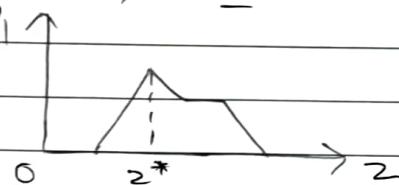
Ans.

Defuzzification is process of producing quantifiable result in crisp logic, given fuzzy sets and corresponding membership degrees.

(1) Max membership Principle :-

- Also known as height method.
- It is limited to peaked out function.

$$\underline{\mu}_c(x^*) \geq \underline{\mu}_c(z) \text{ for all } z \in Z.$$



where z^* is defuzzified value.

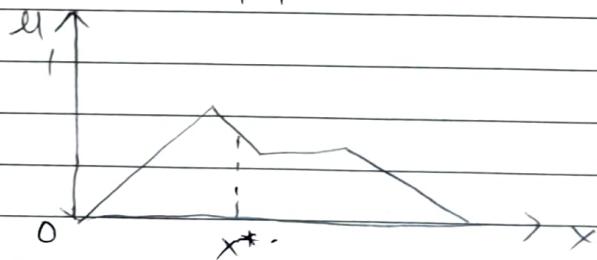
(2) Centroid Method :-

- This method is also known as center of gravity, as it obtains the center of area (x^*)

$$x^* = \frac{\int u(x) \cdot x \cdot dx}{\int u(x) \cdot dx} \text{ for continu.}$$

$$\text{and } x^* = \frac{\sum_{i=1}^n x_i \cdot u(x_i)}{\sum_{i=1}^n u(x_i)} \text{ for discrete.}$$

$$\frac{\sum_{i=1}^n u(x_i)}{\sum_{i=1}^n u(x_i)}$$



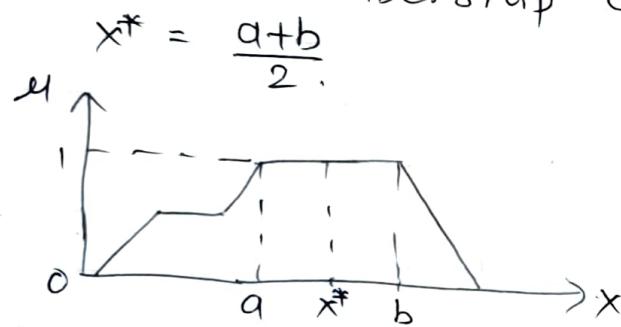
(3) Weighted average method

$$x^* = \frac{\sum \mu_c(\bar{x}) \cdot \bar{x}}{\sum \mu_c(\bar{x})}$$

where \bar{x} is the centroid of each symmetric membership function.

(4) Mean-max membership

This method is called as "middle of maxima" and is closely related to first method, except that locations of maximum membership can be non-unique.



(5) center of sums.

This method is not restricted to symmetric membership function. It is given as x^*

$$x^* = \frac{\sum_{k=1}^n \mu_{ck}(\bar{x}) \cdot \int \bar{x} dx}{\sum_{k=1}^n \mu_{ck}(\bar{x}) \int dx}$$

(6) center of largest area

The center of gravity of convex fuzzy subregion having the target area given as -

$$x^* = \frac{\int \mu_{cj}(x) \cdot x \cdot dx}{\int \mu_{cj}(x) \cdot dx}$$

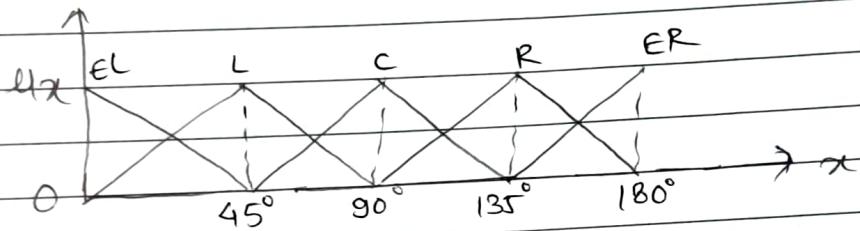


Que. 10)

Step 1) Descriptor for position of mixer tap \Rightarrow Extreme left (EL), Left (L), Center (C), Right (R), Extreme Right
Descriptor for temperature \Rightarrow Very cold (VC), cold (C), Medium (M), hot (H), very hot (VH).

Ans.

Step 2) i) Membership function for position of mixer tap



$$u_{EL}(x) = \frac{45-x}{45}, \quad 0 \leq x \leq 45.$$

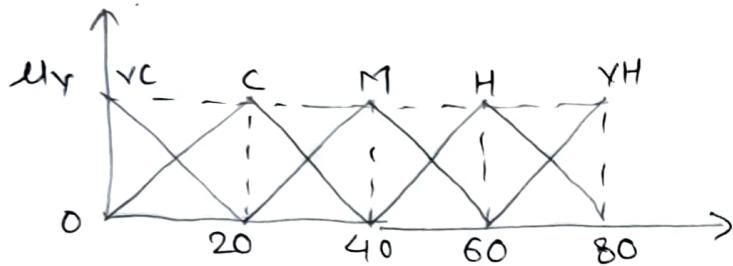
$$u_L(x) = \begin{cases} \frac{x}{45}, & 0 \leq x \leq 45 \\ \frac{90-x}{45}, & 45 < x \leq 90 \end{cases}$$

$$u_C(x) = \begin{cases} \frac{x-45}{45}, & 45 \leq x \leq 90 \\ \frac{135-x}{45}, & 90 < x \leq 135 \end{cases}$$

$$u_R(x) = \begin{cases} \frac{x-90}{45}, & 90 \leq x \leq 135 \\ \frac{180-x}{45}, & 135 < x \leq 180 \end{cases}$$

$$u_{ER}(x) = \begin{cases} \frac{x-135}{45}, & 135 \leq x \leq 180 \end{cases}$$

2. Membership function for temperature.



$$M_{VC}(y) = \frac{20-y}{20}, \quad 0 \leq y \leq 20$$

$$M_C(y) = \begin{cases} \frac{y-20}{20}, & 0 \leq y \leq 20 \\ \frac{40-y}{20}, & 20 < y \leq 40 \end{cases}$$

$$M_M(y) = \begin{cases} \frac{y-40}{20}, & 20 \leq y \leq 40 \\ \frac{60-y}{20}, & 40 < y \leq 60 \end{cases}$$

$$M_H(y) = \begin{cases} \frac{y-60}{20}, & 40 \leq y \leq 60 \\ \frac{80-y}{20}, & 60 < y \leq 80 \end{cases}$$

$$M_{VH}(y) = \begin{cases} \frac{y-80}{20}, & 60 \leq y \leq 80 \end{cases}$$

3. Form a rule box

Input (Tap)	out (water)
-------------	-------------

EL	VC
----	----

L	C
---	---

C	M
---	---

R	H
---	---

ER	VH
----	----



Step 4) Rule Evaluation

Assume position of mixer tap is 80°

This value $x=80^\circ$ maps with.

$$u_L(x) = \frac{90-x}{45} \text{ and } u_C(x) = \frac{x-45}{45}$$

Evaluate $u_C(x)$ for $x=80^\circ$

$$u_L(80) = \frac{90-80}{45} = \frac{2}{9}$$

$$u_C(80) = \frac{80-45}{45} = \frac{7}{9}.$$

Step 5) Defuzzification

By 'mean by max' technique of defuzzification.

$$\max(u_L(x), u_C(x)) = \max\left(\frac{2}{9}, \frac{7}{9}\right) = \frac{7}{9}.$$

This corresponds to rule 3 in rule box

$$u_M(y) = \frac{y-20}{20} \text{ and } u_M(y) = \frac{60-y}{20}$$

$$u_M(y) = \frac{y-20}{20} \therefore \frac{7}{9} = \frac{y-20}{20} \therefore y = 35.55.$$

$$u_M(y) = \frac{60-y}{20} \therefore \frac{7}{9} = \frac{60-y}{20} \therefore y = 44.44.$$

To find final defuzzified value, we now take average of $u_M(y)$.

$$\therefore y^* = \frac{35.55 + 44.44}{2} = 39.995.$$

$$\boxed{\therefore y^* = 40^\circ C}$$

Ques. 11.) compare Mamdani and Sugeno fuzzy model.

Ans.

Mamdani	Sugeno.
1) output membership f^n is present	1) No output membership f^n is present
2) Output surface is discontinuous.	2) Output surface is continuous.
3) Distribution of output.	3) Non-distribution of output.
4) Less flexibility.	4) More flexibility.
5) More accuracy.	5) Less Accuracy.
6) It is using MISO and MIMO.	6) It is using MISO.
7) Application :- Medical diagnosis system.	7) Application :- To keep track of change in aircraft performance with altitude.