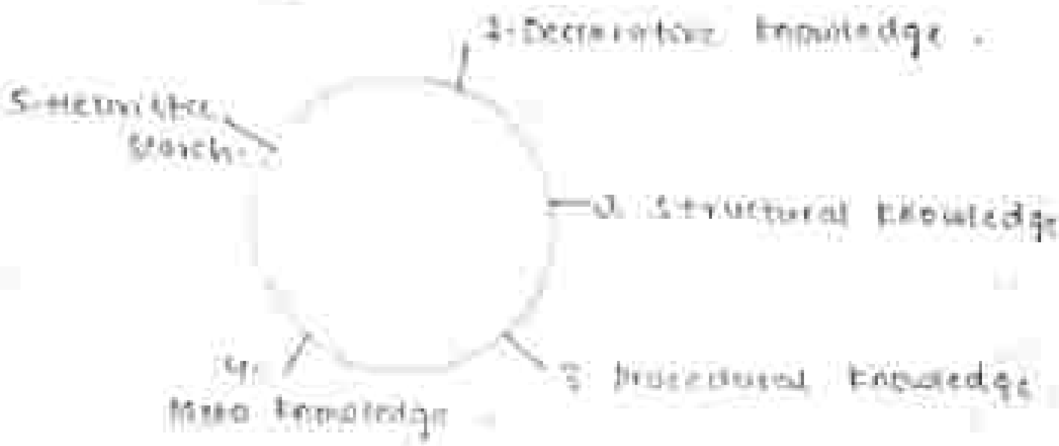
Unit-4 : Knowledge Representation

Knowledge Representation represents the information from the real world for a computer to understand and then utilize the knowledge to solve complex problems, like communicating with human beings in Natural language.

Knowledge Representation means presenting the knowledge that AI system should acquire in different forms.

Types of Knowledge Representation :



1. Declarative Knowledge
2. Structural Knowledge.
3. Procedural Knowledge
4. Meta Knowledge
5. Heuristic Search.

1. Declarative Knowledge :

This includes concepts (related to mathematics), objects and facts expressed in declarative sentence.

Eg: As per Curriculum and academics and respect CSE-B is Best.

Here Concepts = Curriculum, academics

objects = CSE-B.

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2. Structural knowledge.

Basic problem solving knowledge that describes the relationship between concepts and objects.

Eg: Legs, hands, eyes → human.

3. Procedural knowledge.

This includes rules, strategies and procedures etc...

Eg In water jug problem, we have strategies
1. empty
2. fill and
3. transfer

and the condition is no jug is overflown. and by using these strategies and rules an agent perform process.

4. Meta knowledge.

Meta knowledge consists knowledge other than structural and procedural knowledge.

Eg: Other than teaching teacher doing attendance, admissions etc... comes under meta knowledge of a teacher.

5. Heuristic knowledge.

This is based on expert's knowledge. It represents initial and final states.

Semantic Network

1. It is a graphical representation for representing knowledge in patterns of interconnected nodes.

There are 2 types of semantic networks.

1. Simple semantic network.
2. Partitioned semantic network.

1. Simple semantic network

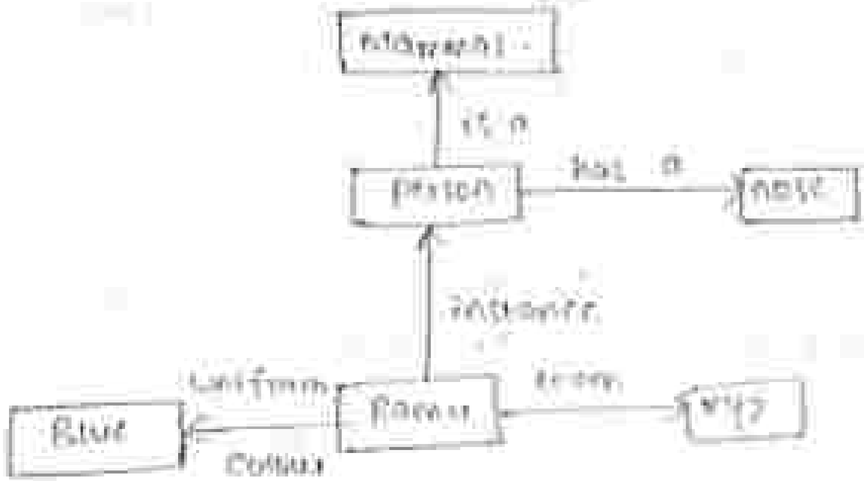
It consists of the following things:

$\xrightarrow{\text{has a}}$

$\xrightarrow{\text{is a}}$

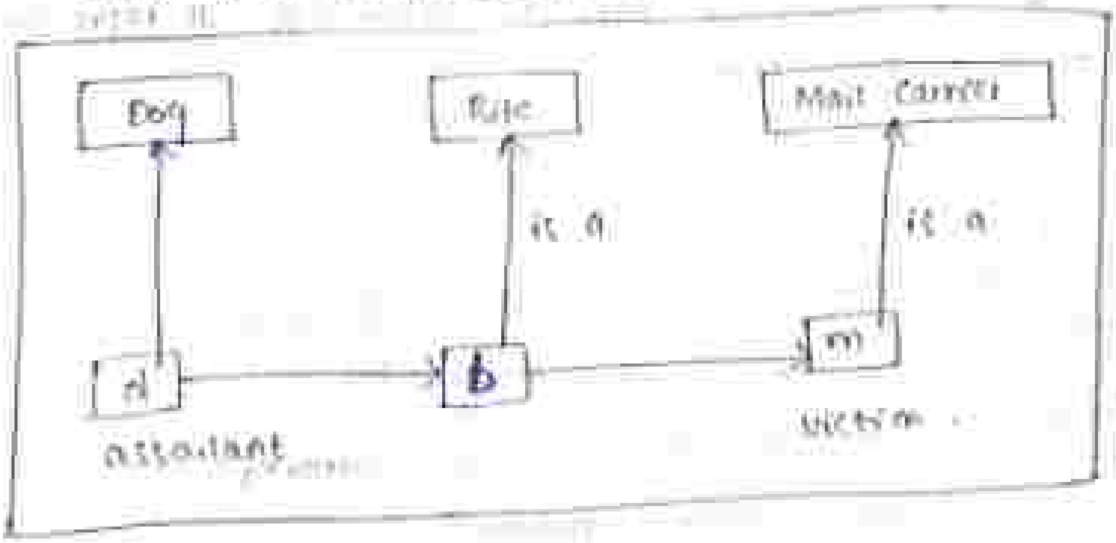
$\xrightarrow{\text{instance}}$

Eg: Create a simple semantic network for a class mammal person class inherits properties of class mammal. Person class as instance named Ramu who in the team XYZ having blue colour uniform and person class has a characteristic nose

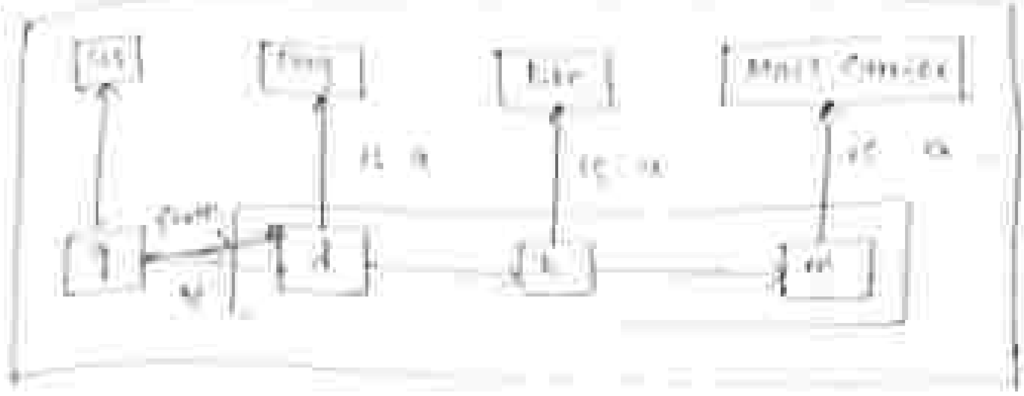


2. partition semantic network

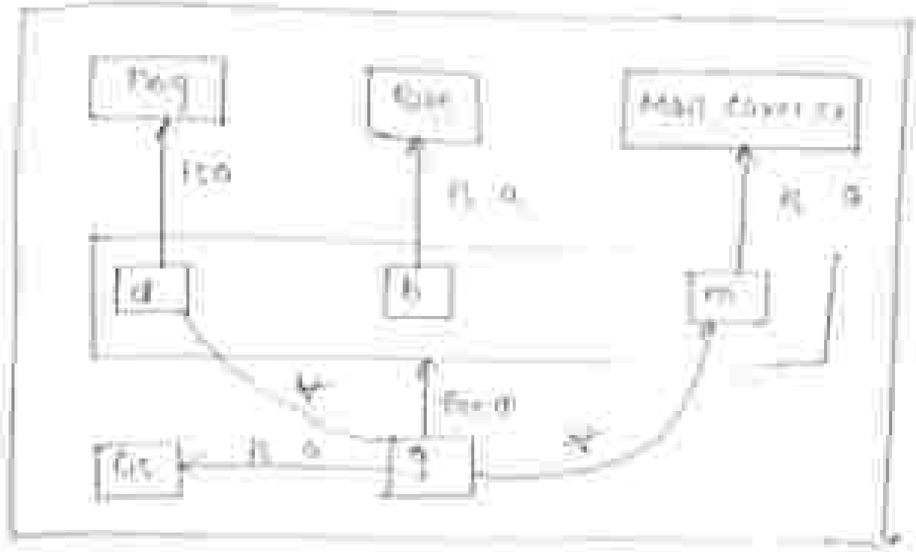
Eg: Draw a partition semantic network for the dog bites mail_carrier(postman)



Every dog has bitten a mail carrier.



Every dog in town has bitten every mail carrier.



Knowledge Representation using Frames:

These frames are nothing but slot fillers. Slots that have the slot fillers (attribute values) ... [illegible]

Eg. Employee record

In database we have the rows (record) ... [illegible] ... data are stored.

Name	Designation	Salary	Address
Ravi	Manager	1110	Delhi

Represent the given statement in terms of frames:

(inspection (values, monitors))
(repair (value, lathe))

(Address (value, Delhi))

)

Eg 2:

Swiggy is yellow bird having wings to fly.

Swiggy (

(species (value, bird))

(colour (value, yellow))

(activity (value, fly))

(instrument (value, wings))

)

Techniques of Logical Representation:

1. Logical Representation:

In logical representation we have 2 types.

1. Proposition logic

2. predicative logic

using logical representation we write the simplified form of given statements.

Proposition logic

here we use symbols like V, Λ, ~, →, ↔

Eg: If you work hard then you will achieve everything

This sentence is written by using propositional logic as

work hard ⟶ will achieve everything

predicate logic:

It is an extension to propositional logic. Other than V, Λ, →, ↔, ~ we have quantifiers as ∀, ∃

Eg: All Students like Ice Cr.

$\forall (Student(x) \longrightarrow likes(x, Ice\ cr))$

2. Semantic Network Representation:

It is a graphical representation for representing knowledge in patterns of interconnected nodes.

there are two types of Semantic Networks.

1. Simple Semantic Network
2. partition semantic network.

1. **Simple Semantic Network:**

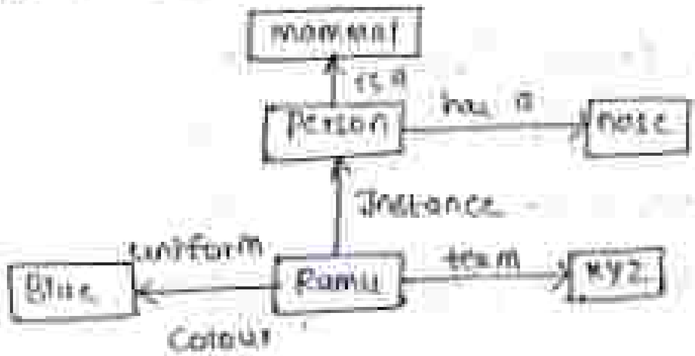
It consists of the following things:

$\xrightarrow{\text{has a}}$

$\xrightarrow{\text{is a}}$

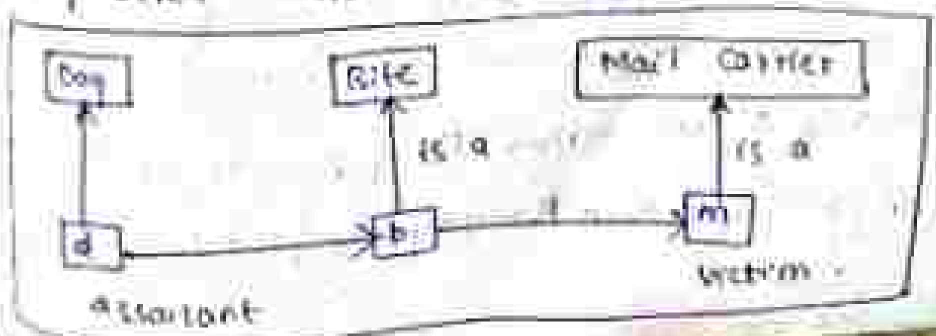
$\xrightarrow{\text{instance}}$

Eg: Create a simple Semantic network for a class mammal person class inherits properties of class mammal. person class as instance named Ramu, who is the team xyz having blue colour uniform and person class has a characteristic nose.



Partition Semantic Network:

Eg: Draw a partition Semantic network for the dog bites mail carrier (postman).



3 Frame Representation:

Here frames are collection of records [illegible]. It has attributes that have their values (attributes) relevant for an entity.

Eg: Employee details

In database we have the table shown below which consists only one record.

Name	Profession	Empid	Address
Ravi	Manager	1010	Delhi

Convert the given statement in terms of frames.

Ravi(
(Profession, (value, Manager))
(Empid, (value, 1010))
(Address, (value, Delhi))
)

Eg:2
Swiggy is yellow bird having wings.

Swiggy(
(Species (value, Bird))
(Colour (value, yellow))
(Activity (value, fly))
(Instrument (value, wings))
)

4. Production rules:

Production rules system consist of condition - Action pairs which means "If condition then Action".

Eg: If (at busstop ∧ bus arrives) then (get into the bus)

If (in the bus ∧ paid ∧ empty seat) then (sit down) if (in bus stopped) then (pay charges)

if (he arrived at destination) then (get down from the bus)

Case Grammars

Case grammars was proposed by J. Fillmore in 1968. as it is a linguist (the rules on languages).

He proposed 6 cases

1. AGENTIVE (Agent)
2. OBJECTIVE (object)
3. INSTRUMENTAL (Instrument)
4. DATIVE (Indirect object)
5. FACTIVE (result of action)
6. LOCATIVE (Location of action)

Tabular way to represent cases

Case	Question
Action	What was the event occured?
Agent	Who did the event?
Objective	What was involved in the event?
Beneficial	Who got benefited with the event?
time	Which time event was occured?
location	Where it was happened?

Example

John gave an apple to Mary in the kitchen.

Action - give

Agent - John.

Objective - apple

Beneficial - Mary

Time - past

Location - kitchen.

Here case grammar states that whether the two statements are semantically (or) syntactically equal (or) same.

eg: Given statements are:

(i) The door was broken by John with hammer.

(ii) using hammer John broken the door.

Note:

If both the statements i.e sentences convey the same meaning but may be of different forms then, they are called semantically equal.

eg: (i) Mother baked for one hour.

(ii) cake baked for one hour.

Note:

In the above statements initial object of the statement is different and rest is same thus this statements are syntactically equivalent (or) equal.

Script:

Event: Student attending exam.

The components provided by the script are:

1. Roles:

These are the persons included in the event i.e Student.

2. Props:

Objects which are involved in the event. i.e pen, pencils, Idcard, paper, Question paper etc..

3. Entry condition.

Entry conditions are the conditions needed to be satisfied before an event occurred i.e idcard, hallticket

→ **Effects:**

Conditions that will be true after event occurs.

i.e. After receiving question paper, he will conditions the answers need to investigation.

Themes:

Themes are nothing but variations of the event i.e. AIEEE exam, B.Tech exam, SSC exam, MBA, Supply, Regular etc.

Scenes:

These are the sequence of actions occurred in event.

i.e. Scenes:

Exam hall entry
↓
Getting allotted seat
↓
Getting question paper
↓
~~answering~~ writing answers
↓
Submitting answer sheet.

Semantic Web:

The Semantic web is an extension of traditional web. It provides a communication to the user and server allowing the data to share to design web pages we use, hyper text mark up language. But the disadvantage is we cannot use the user defined task. We use only predefined task. So, that we use extensible markup language. It is an extension of HTML.

Eg:

```
<circular>
        <to>faculty</to>
        <from>head</from>
        <headline>faculty meeting</headline>
        <body>there is meeting of faculty
              in room no 17 on
              17/11/14</body>
</circular>
```

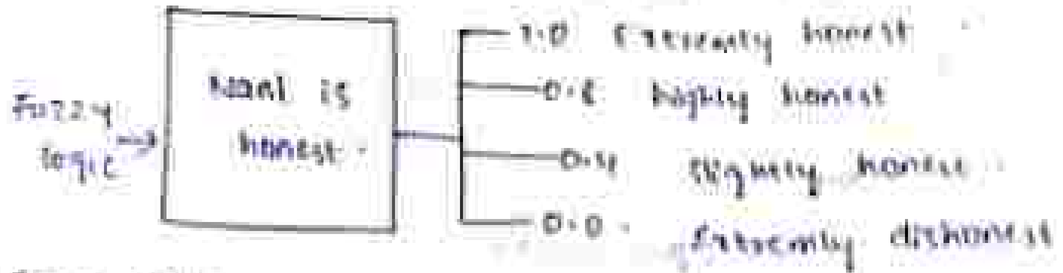
XML Schema:

```
<book>
        <title>.......</title>
        <author>.....</author>
        <abstract>......</abstract>
</book>
```

Fuzzy logic:

It is an approach based on degree of truth rather than true or false.

In traditional logic that is predicate and propositional logic, every statement has a truth value that is true or false.



Fuzzy set:

A regular set is nothing but collection of related items.

Eg: Fruit = { Guava, apple, banana, fig }

Here Guava, apple, banana, fig are element of the fruit.

Fuzzy set:

Fuzzy set is a collection of membership and its degree of truth (truth value).

Eg: $A = \{ \overset{0.4}{\text{train}}, \overset{0.6}{\text{car}}, \overset{0.7}{\text{cycle}} \}$ $1.0 = C$

Membership train slightly belong to set A

Membership car highly belongs to set A

Membership cycle extremely belongs to set A

Linguistic variable

Linguistic variable is a variable which stores words.

Eg. Age = {child, young, old}

The formal definition of a linguistic variable is

$(x, T(x), U, G, M)$.

Where

x: variable name

$T(x)$: set of values x takes.

U: all values a variable can take

G: syntactic rules.

M: semantic rules.

Eg. Age = {child, young, old}.

x: Age

$T(x)$: child, young, old.

U: set of ages of all people.

M: give meaning to each term.

$M_{child}(x)$: $x \leq 15$

$M_{young}(x)$: $15 \leq x \leq 35$

$M_{old}(x)$: $35 \leq x \leq 100$.

Fuzzy propositions.

P: Ram is a boy.

$T(P) = 0.8$.

$\bar{P}$: Ram is not a boy.

$T(\bar{P}) = 1 - T(P)$

$= 1 - 0.8$

$= 0.2$

Fuzzy Proposition is nothing but a proposition with a truth value.

We can modify given proposition and we can combine the given proposition and we can given propositions.

Q: Ram is intelligent.

$T(Q) = 0.6$.

And my new proposition is

$P \wedge Q$: Ram is lazy and Ram is intelligent

$\therefore T(P \wedge Q) = \min(T(P), T(Q))$

$= \min(0.8, 0.6)$

$T(P \wedge Q) = 0.6$

Fuzzy set operations:

The operations performed between Fuzzy set are

1. Union
2. Intersection
3. Complementary
4. difference.

Union:

If $\underset{\sim}{B_1}$ and $\underset{\sim}{B_2}$ are two fuzzy sets then.

$$\underset{\sim}{B_1} \cup \underset{\sim}{B_2} = \text{Max}\left[\mu_{B_1}(x), \mu_{B_2}(x)\right]$$

$$\underset{\sim}{B_1} = \left\{\frac{1}{1.0} + \frac{0.75}{1.5} + \frac{0.3}{2.0} + \frac{0.15}{2.5} + \frac{0}{3.0}\right\}$$

$$\underset{\sim}{B_2} = \left\{\frac{1}{1.0} + \frac{0.6}{1.5} + \frac{0.2}{2.0} + \frac{0.1}{2.5} + \frac{0}{3.0}\right\}.$$

$$\underset{\sim}{B_1} \cup \underset{\sim}{B_2} = \left\{\frac{1}{1.0} + \frac{0.75}{1.5} + \frac{0.3}{2.0} + \frac{0.15}{2.5} + \frac{0}{3.0}\right\}.$$

Intersection.

$$\underset{\sim}{B_1} \cap \underset{\sim}{B_2} = \text{Min}\left[\mu_{B_1}(x), \mu_{B_2}(x)\right].$$

$$\underset{\sim}{B_1} \cup \underset{\sim}{B_2} = \left\{\frac{1}{1.0} + \frac{0.6}{1.5} + \frac{0.2}{2.0} + \frac{0.1}{2.5} + \frac{0}{3.0}\right\}$$

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Complement :

$$\overline{\underset{\sim}{B_1}} = \{1 - \mu_{B_1}(x)\}$$

Subtracting numerator from 1

$$\overline{\underset{\sim}{B_1}} = \left\{ \frac{0}{1.0} + \frac{0.25}{1.5} + \frac{0.7}{2.0} + \frac{0.85}{2.5} + \frac{1}{3.0} \right\}.$$

$$\overline{\underset{\sim}{B_2}} = \{1 - \mu_{B_2}(x)\}$$

$$\overline{\underset{\sim}{B_2}} = \left\{ \frac{0}{1.0} + \frac{0.4}{1.5} + \frac{0.6}{2.0} + \frac{0.9}{2.5} + \frac{1}{3.0} \right\}.$$

Difference :

$$\underset{\sim}{B_1} \,|\, \underset{\sim}{B_2} = \underset{\sim}{B_1} \cap \overline{\underset{\sim}{B_2}}$$

$$\underset{\sim}{B_1} \cap \overline{\underset{\sim}{B_2}}$$

$$= \left\{ \frac{1}{1.0} + \frac{0.75}{1.5} + \frac{0.3}{2.0} + \frac{0.15}{2.5} + \frac{0}{3.0} \right\} \cap$$

$$\left\{ \frac{0}{1.0} + \frac{0.4}{1.5} + \frac{0.6}{2.0} + \frac{0.9}{2.5} + \frac{1}{3.0} \right\}.$$

→ Min we have to write as it is intersection

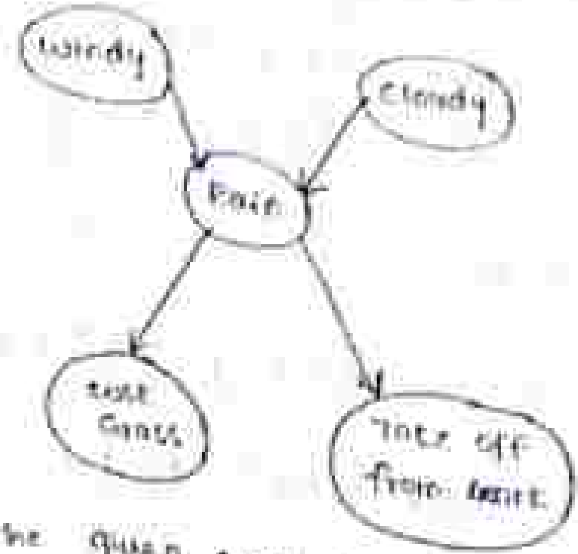
$$= \left\{ \frac{0}{1.0} + \frac{0.4}{1.5} + \frac{0.3}{2.0} + \frac{0.15}{2.5} + \frac{0}{3.0} \right\}.$$

Suppose

$$\underset{\sim}{B_2} \,|\, \underset{\sim}{B_1} = \underset{\sim}{B_2} \cap \overline{\underset{\sim}{B_1}}$$

Bayesian Belief Network :

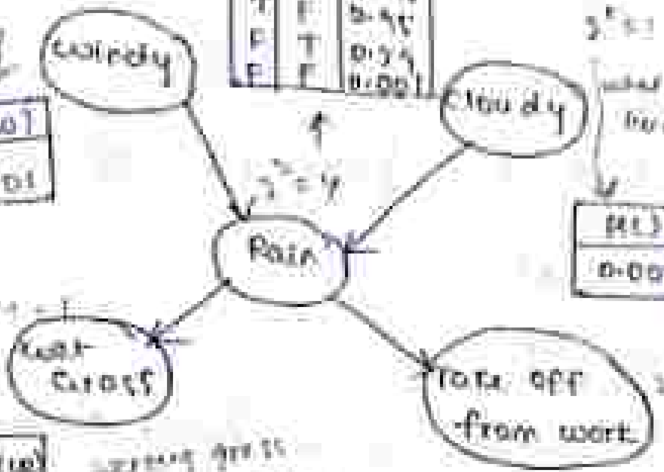
It is a probabilistic graphical model that represents the conditional dependencies between variables through a directed acyclic graph.



Q) From the given graph. Find the probability of grass getting wet.

W	C	P(R)
T	T	0.95
T	F	0.95
F	T	0.29
F	F	0.001

$2^2 = 4$



$2^0 = 1$

P(W)
0.01

$2^0 = 1$

P(C)
0.002

$2^1 = 2$

R	P(W)
T	0.9
F	0.05

$2^1 = 2$

R	P(W)
T	0.3
F	0.01

Probability of Grass getting wet

$$P(W) = P(W/R) * P(R) + P(W/\bar{R}) * P(\bar{R})$$

$$= 0.9 * P(R) + 0.05 * P(\bar{R})$$

$$P(R) = P(R|W_C) * P(W \wedge C) + P(R|\bar{W}_C) * P(\neg W \wedge C) + P(R|W\bar{C}) * P(W \wedge \neg C) + P(R|\bar{W}\bar{C}) + P(\neg W \wedge \neg C)$$

$$\boxed{\text{Note: } P(W \wedge C) = P(W) * P(C)}$$

$P(R) = 0.95 * 0.001 * 0.002 + 0.29 * (1-0.001) *$
$0.002 + 0.95 * 0.001 * (1-0.002) +$
$0.001 * (1-0.001) * (1-0.002)$

$= 0.00252$

$P(\bar{R}) = P(\bar{R} \mid W, C) * P(W \wedge C) + P(\bar{R} \mid \bar{W} C) * P(\bar{W} \wedge C)$
$+ P(\bar{R} \mid W\bar{C}) * P(W \wedge \bar{C}) + P(\bar{R} \mid \bar{W}\bar{C}) *$
$P(\bar{W} \wedge \bar{C})$

$= 0.99744$

Substituting these in (1) we get

$P(W) = (0.9 * 0.00252) + (0.05 * 0.99744)$

$= 0.0521$

Dempster Shafer Theory:

In this concept we use a term called Plausibility ~~indicated~~ by "θ"
indicated

Here we use a term called probability density indicated by "m".

Eg:
Here Plausibility have the elements Allergy, flue, cold, pneumonia represented as below

θ = {Allergy, flue, cold, pneumonia}.

To diagnose for a person to be fever elements need are flue, cold, pneumonia, represented by probability density "m".

m = { fever, cold, pneumonia }

∴ m = 0.6

here probability of m = 1

probability of m = 0.4.

here we values are used as the elements of set 'θ'

Dempster Shafer theory gives the probability of unnecessary things

Total wastage = 1 - 0.6
sample = 0.4.

→ For the diagnosis of running nose:

m = { Allergy, fever, cold }

m = 0.6

wastage = 1 - 0.6

= 0.4

→ For the diagnosis of Asthma:

m = { Allergy, cold, pneumonia }

m = 0.4

wastage = 1 - 0.4

= 0.6.

Certainty Factor:

Certainty factor gives the probability of given statement is true.

To calculate certainty factor we have two things

1. Measure of belief.

2. Measure of disbelief.

Measure of Belief (MB):

$MB[H,E] = 0$

H = Hypothesis

E = Evidence

This states that for given evidence, hypothesis is false.

$MB[H,E] = 1$

This states that for provided evidence, hypothesis is true.

Measure of Disbelief (MD):

$MD\{H,E\} = 0$

This states that for the provided evidence, the hypothesis is true.

$MD[H,E] = 1$

This states that for the provided evidence, the hypothesis is false.

Multiple evidences single hypothesis.

$$MB[H, E_1 \text{ and } E_2] = MB[H,E_1] + MB[H,E_2] * [1 - MB(H,E_1)]$$

$$MD[H, E_1 \text{ and } E_2] = MD[H,E_1] + MD[H,E_2] * [1 - MD(H,E_1)]$$

$$CF[H, E_1 \text{ and } E_2] = MB(H, E_1 \text{ and } E_2) - MD(H, E_1 \text{ and } E_2).$$

Calculate the certainty factor by having the values given.

$MB[H,E_1] = 0.4$; $MD[H,E_1] = 0$.

$MB[H,E_2] = 0.3$ $MD[H,E_2] = 0.1$

certainty factor

MB[h, E1 and E2]

= [illegible]

= [illegible]

= [illegible]

= [illegible]

MD[h, E1 and E2]

= 0 + 0.1 * (1 - 0)

= 0.1

CF = [illegible] - 0.1

= [illegible]

Types of membership functions:

Triangle:

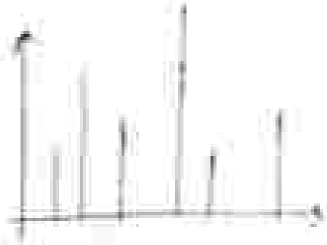
A fuzzy set consists of membership with truth values, when we plot all these truth values in a graph, if it represents as the graph shown above then we call a fuzzy set of membership type "triangular".

Trapezoidal:

A fuzzy set consists of membership with truth values, when we plot these truth values in a graph, if it represents as the graph shown above then we call a fuzzy set of membership type "trapezoidal".

3. Singleton:

A fuzzy set consists of membership with truth values and when we plot these truth values if we get graph as above called "singleton".

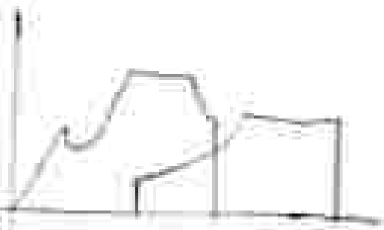


4. Gaussian:

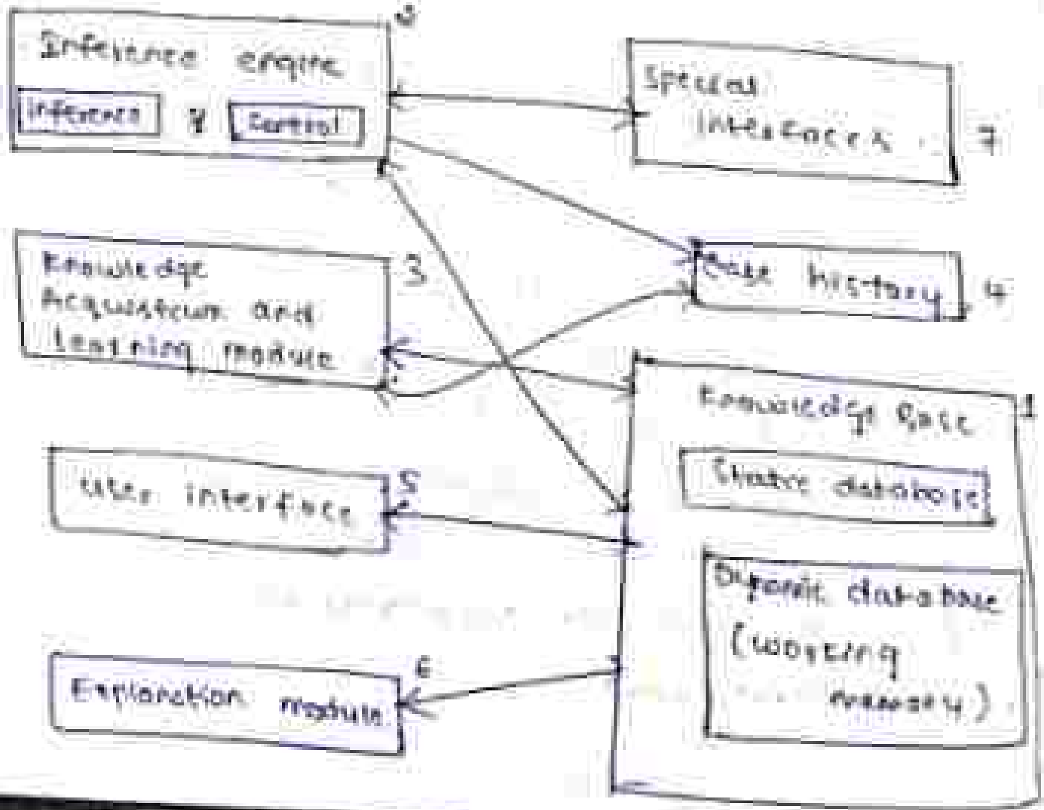
A fuzzy set consist of membership with truth values and when we plot these truth values if we get graph as above it called "Gaussian".

5. piece wise linear:

A fuzzy set consist of membership with truth values and when we plot these truth values if we get graph as above it called "piece wise linear".



Expert Systems:



knowledge base:

It is a database of the expert system.

It is of 2 types.

1. Static database.

"The pre-written AI programs and classes are stored here

2. Dynamic database:

"The intermediate results while solving problem is stored here.

Inference Engine:

It has 2 components.

1. Inference.

Bringing data from secondary to primary memory.

2. Control."

Responsibility of applying the rules to solve the particular problem.

knowledge Acquisition and Learning Module

Acquisition means addition to add knowledge to expert system we have to make the system learn.

Special Interfaces:

Delivery of the solution without complete information.

Case History:

Statements converted in the form of cases are stored here.

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User Interface:

This module helps the communication between machine and human.

Eg: User: hi

Machine: hi

Explanation module

This module explains the user why it came to conclusion.

Eg: Machine: Are you depressed?

User: why are you asking?

Machine: your looks were different.

User: yes.

Machine: By seeing your looks I am concluding that you are depressed.