

Knowledge and Reasoning

Unit 3

Knowledge Base

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

What is Knowledge?

The data is collection of facts. The information is organized as data and facts about the task domain. **Data, information, and past experience** combined together are termed as knowledge

- Components of Knowledge Base
- The knowledge base of an ES is a store of both, factual and heuristic knowledge.
- **Factual Knowledge** – It is the information widely accepted by the Knowledge Engineers and scholars in the task domain.
- **Heuristic Knowledge** – It is about practice, accurate judgement, one's ability of evaluation, and guessing.

Knowledge representation

- The classic methods of representing knowledge use either rules or logic.
- It is the method used to organize and formalize the knowledge in the knowledge base. It is in the form of IF-THEN-ELSE rules.
- The KB representation should be able to handle this sort Of environment, "here limited or partial Information is available the beginning and later on. more information is evolved.

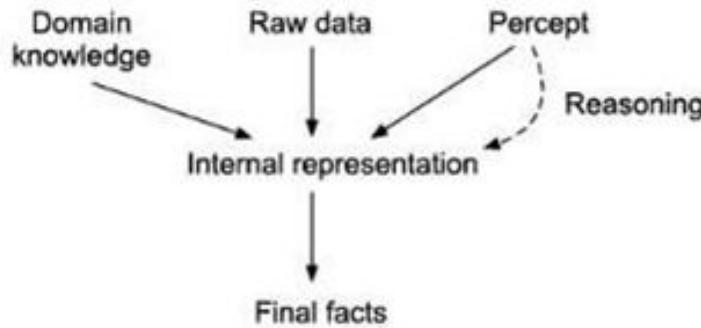


Fig.1 Knowledge building and representation

Approaches and Issues of knowledge representation

Approaches

- While designing a system for knowledge representation we would always go for a system that allows representation of the entire knowledge, which is required with respect to the application or domain we work on, usually known as adequacy in terms of representation.
- It needs to be efficient in terms of inferring, where the additional data is used in direction of better inferring.
- The representation need to be adaptive and also available at the point of time.

Approaches

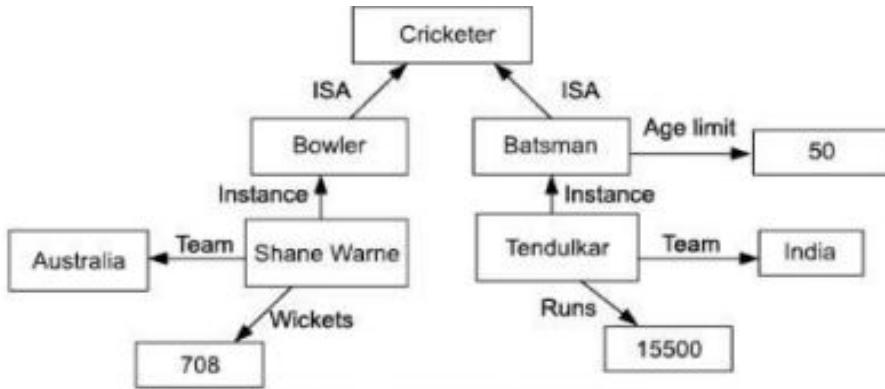
Relational knowledge structure

- The facts are mapped into the relations and stored in the database
- It is the weak inference mechanism

<i>Employee</i>	<i>Salary</i>	<i>Experience</i>
Sameer	30000	3
Kavita	20000	2
Jasmin	20000	2

Inheritable knowledge structure

- Relational knowledge is made up of objects consisting of attributes and corresponding associated values.
- Property inheritance
 - elements inherit values from being members of a class.
 - data must be organised into a hierarchy of classes



- Boxed nodes -- objects and values of attributes of objects.
 - Values can be objects with attributes and so on.
 - Arrows -- point from object to its value.
 - This structure is known as a slot and filler structure, semantic network or a collection of frames.
- *This structure is also called the slot-filler structure*

Inferential knowledge structure

- First order logic is used for better utilization of knowledge

	Rule	First-order logic
R1	IF animal has hair THEN species is mammal	$\forall x \text{Has_hair}(x) \Rightarrow \text{Mammal}(x)$
R2	IF animal gives milk THEN species is mammal	$\forall x \text{Gives_milk}(x) \Rightarrow \text{Mammal}(x)$
R3	IF animal eats meat THEN species type is carnivore	$\forall x \text{Eats_meat}(x) \Rightarrow \text{Carnivore}(x)$
R4	IF animal has pointed teeth AND animal has claws AND animal has forward eyes THEN species type is carnivore	$\forall x \text{Has_pointed_teeth}(x) \wedge \text{Has_claws}(x) \wedge \text{Has_forward_eyes}(x) \Rightarrow \text{Carnivore}(x)$
R5	IF animal is mammal AND animal has hooves THEN mammal group is ungulate	$\forall x \text{Mammal}(x) \wedge \text{Has_hooves}(x) \Rightarrow \text{Ungulate}(x)$

Procedural knowledge structure

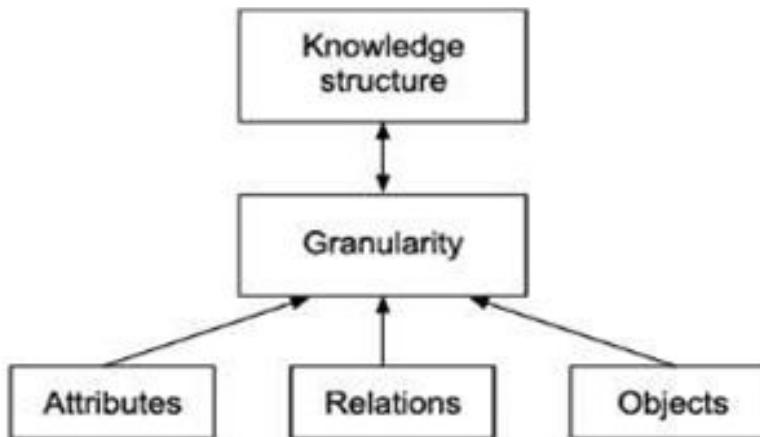
- It is used when we need to have knowledge in detailed form
- Programming languages are used(LISP is the most common language used for this purpose).

Issues

Issues that arises while KR techniques:

- **Important Attributes:**
 - Most important Attributes have an impact on the representation
 - So it is important understand and identify these attributes
- **Relationships among Attributes.**
 - Identifying the relationships among the attributes is equally important
 - The relationship between the attributes of an object, independent of specific knowledge they encode, may hold properties like : Inverse, Existence in an isa hierarchy , Technique for reasoning about values and Single valued attributes
- **Choosing the granularity of Representation.**
 - Up to what depth the mapping of the knowledge is to be done.

- Representing Sets of Objects.
 - The reason to represent sets of objects is: if a property is true for all or most elements of a set, then it is more efficient to associate it once with the set rather than to associate it explicitly with every elements of the set.
- Finding the Right structures as Needed.
 - Given a large amount of knowledge stored in a database, how can relevant parts are accessed when they are needed?
 - This is about access to right structure for describing a particular situation.
 - This requires, selecting an initial structure and then revising the choice.



Knowledge based agent

- A knowledge-based agent includes a knowledge base and an inference system.
- A knowledge base is a set of representations of facts of the world.
- Each individual representation is called a **sentence**.
- The sentences are expressed in a **knowledge representation language**.
- The agent operates as follows:
 1. It TELLS the knowledge base what it perceives.
 2. It ASKS the knowledge base what action it should perform.
 3. It performs the chosen action.

Logic

Logic involves syntax, semantics as well as inference procedures.

There is a need to define logical involvement in two sentences or facts

Ex: Assume x and y two sentences whose relationship is to be determined. So let us map this relationship as follows:

$$x \models y$$

This indicates that the sentence x entails y , indicating that in the model when x is true the y is also true.

Propositional logic

- One popular choice is use of logic.
- Propositional logic is the simplest.
 - Symbols represent facts: P, Q, etc..
 - These are joined by logical connectives (and, or, implication) e.g., $P \wedge Q; Q \Rightarrow R$
 - Given some statements in the logic we can deduce new facts (e.g., from above deduce R)

Propositional logic

- Syntactic Properties of Propositional Logic
 - If S is a sentence, $\neg S$ is a sentence (negation)
 - If S_1 and S_2 are sentences, $S_1 \wedge S_2$ is a sentence (conjunction)
 - If S_1 and S_2 are sentences, $S_1 \vee S_2$ is a sentence (disjunction)
 - If S_1 and S_2 are sentences, $S_1 \Rightarrow S_2$ is a sentence (implication)
 - If S_1 and S_2 are sentences, $S_1 \Leftrightarrow S_2$ is a sentence (bi-conditional)

Semantic Properties of Propositional Logic

- $\neg S$ is true iff S is false
- $S_1 \wedge S_2$ is true iff S_1 is true and S_2 is true
- $S_1 \vee S_2$ is true iff S_1 is true or S_2 is true
- $S_1 \Rightarrow S_2$ is true iff S_1 is false or S_2 is true
- i.e., is false iff S_1 is true and S_2 is false
- $S_1 \Leftrightarrow S_2$ is true iff $S_1 \Rightarrow S_2$ is true
and $S_2 \Rightarrow S_1$ is true

UNIT-3

Knowledge

Intelligence

Reasoning

Knowledge Representation

Knowledge Based Agents

The Wumpus World.

- Syntax - Grammatical error (wrong inference)

- Semantic - Meaning (I watched book while reading TV)

Machine acts acc. to knowledge fed into it.

Logic 1. Propositional (T/F)
2. Predicate (#)

Rules → if
then

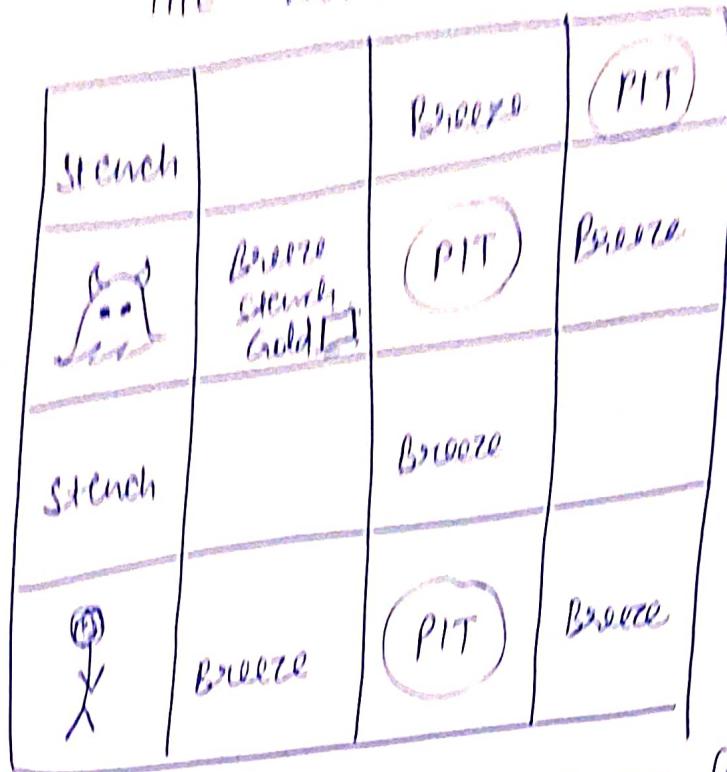
Semantics Net → Google Graph
→ meaning graph e.g. Cat has 4 legs
Tiger also has.

Frames → Slots & fillers
↓ ↓
obj attributes

Script Advancement of Frames

→ given to agent so that it can take decisions.

THE WUMPUS WORLD



intro :- Wumpus, Stench, Agent, Pit, Breeze, Gold, Arrow

Awards & Punishments :-

- (1) +100 Points if Agent comes back with Gold
- (2) -1 point on agents every action
- (3) -10 pts. if arrow is used
- (4) -200 pts. if agent dies

PENS properties:-

Performance Measure:- (All above 4 pts.)

Environment :- Empty Rooms, Room with Wumpus, Stenchy Room, Breezy rooms, Rooms with Gold, Arrow.

Sensors :- Camera, Odour sensors, Audio sensors

Effectors :- Motor to move R,L,U,D., Robotic arm to grab gold, robotic mechanism to shot arrow.

Predicate logic

① Marcus was a man
man (Marcus)

② Marcus was a Pompeian
Pompeian (Marcus)

③ All Pompeians were Romans
 $\forall x : \text{Pompeian}(x) \rightarrow \text{Roman}(x)$

④ Caesar was a ruler
ruler (Caesar)

⑤ All Romans were either loyal to Caesar or hated him

$\forall x : \text{Roman}(x) \rightarrow$
if x is roman $\begin{cases} \text{loyal to } (x, \text{Caesar}) \\ \vee \text{ hate } (x, \text{Caesar}) \end{cases}$

⑥ Everyone is loyal to someone.

$\forall x, \exists y : \text{loyal to } (x, y)$

everyone someone ②

⑦ People only try to assassinate rulers they are not
loyal to

$\forall x, \forall y : \text{People}(x) \wedge \text{ruler}(y) \wedge \text{try assassinate}$
People ruler (x, y)

try to ass
who are loyal (x, y)

⑧ Marcus tried to assassinate Caesar
try assassinate (Marcus, Caesar)

Prove : Marcus hated Caesar
hate (Marcus, Caesar)

Resolution in Predicate logic

① John likes all kinds of foods
PL $\Rightarrow \forall x : \text{food}(x) \rightarrow \text{likes}(\text{John}, x)$
 $\neg \text{food}(x) \vee \text{likes}(\text{John}, x)$

Clause form
if $a \rightarrow b = \neg a \vee b$

② Apples are food
food (apple)

Clause form, same

FORWARD CHAINING & BACKWARD CHAINING

Q) Prove that Robert is a criminal.

FACTS :-

- It is crime for an American to sell weapons to the enemy of America.

• Country China is an enemy of America. $\Rightarrow \underline{\text{Enemy (China, America)}}$

• China has some missiles. $\Rightarrow \underline{\text{Owns (China, x)}}$

• All the missiles were sold to China by Robert.

• Missile is a weapon

• Robert is American

FACTS TO FOL :-

$\Rightarrow \text{American}(x) \wedge \text{Weapon}(y) \wedge \text{sell}(x, y, z)$

$\wedge \text{enemy}(z, \text{America}) \Rightarrow \text{criminal}(x)$

$\Rightarrow \underline{\text{missile}(x)}$

$\Rightarrow \underline{\text{sell}(Robert, x, China) \wedge \text{Owns}(\text{China}, x)}$

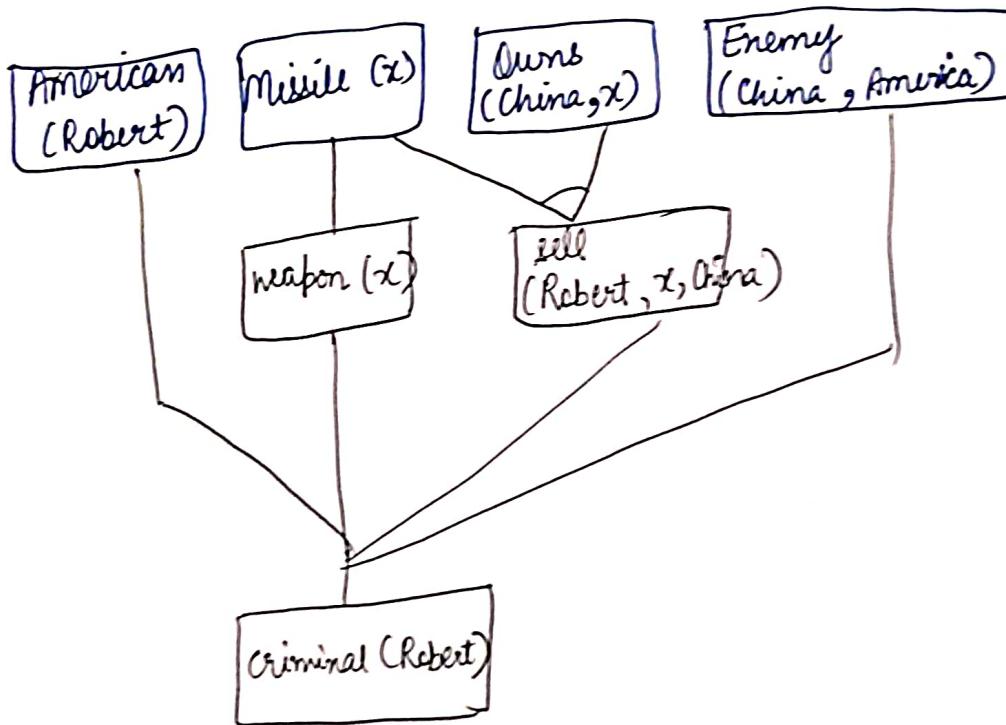
$\Rightarrow \underline{\text{sell}(Robert, x, China)}$

$\Rightarrow \underline{\text{missile}(x) \Rightarrow \text{weapon}(x)}$

$\Rightarrow \underline{\text{American (Robert)}}$

Proof by Forward Chaining :- (Initial state to Goal State)

- Data Driven



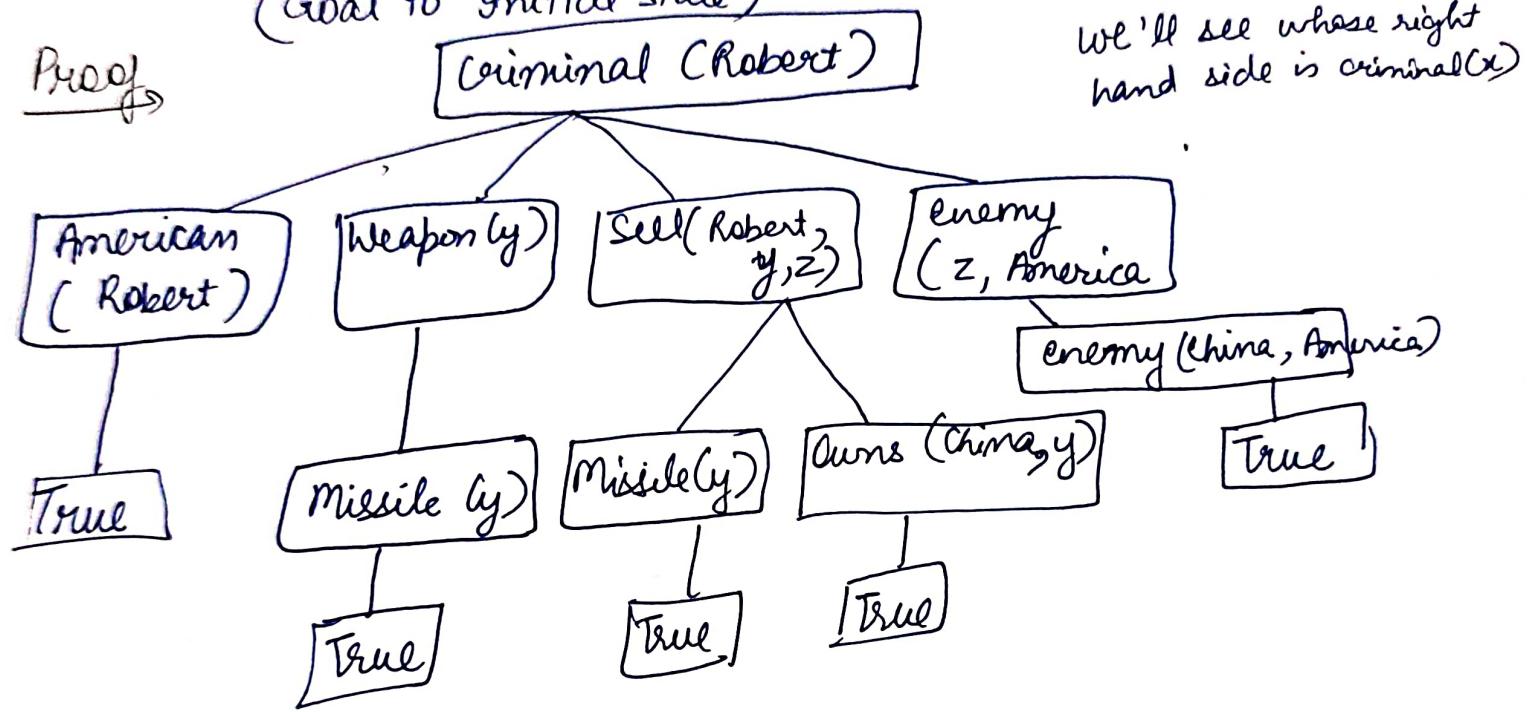
When based on the available data, a decision is taken then the process is called forward chaining.

It works from initial state to goal state.

Backward Chaining

Decision driven / goal driven
(Goal to Initial State)

Proof



UNIFICATION & RESOLUTION

Unification stands for making of expressions to look ~~to look~~ identical.
It can be done with the process of substitution.

$$\text{e.g. } p(x, f(y)) \xrightarrow{\quad} ①$$

$$p(a, f(g(z))) \xrightarrow{\quad} ②$$

[① and ② will be identical if x is replaced with a ,
and y is replaced with $g(z)$.]

Unification \rightarrow $\left[\begin{array}{c} p(a/x) \\ \underbrace{a/x, g(z)/y} \end{array} \right]$

Substitution set

Conditions for Unification :-

- ① Predicate symbol must be same. (p in both equations above)
- ② Number of arguments in both expressions must be identical. $\begin{bmatrix} p(-, -) \\ p(-, -, -) \end{bmatrix}$ \times unif. can't be performed because arg. no. is not same
- ③ If two similar variables present in same expⁿ, then unification fails. [x, a in above e.g.]

Algorithm for Unification :-

Unify (A_1, A_2)

- ① If A_1 or A_2 is variable / constant
 ↳ if A_1 and A_2 are identical
 return NIL

↳ Else if A_1 occurs in A_2
 return FAIL

↳ Else return $\boxed{A_2/A_1}$ (A_1 replaced by A_2)

↳ Check for A_2 in A_1

↳ fail if A_2 occurs in A_1

↳ else return $\boxed{A_1/A_2}$ (A_2 replaced by A_1)

- ② If Predicate is not same

- ③ If diff. ^{no. of} arguments
 then FAIL

- ④ Else SUBSTITUTE to NIL

- ⑤ LOOP

- ⑥ Return

D.Y.S.
 $\underline{\underline{Q}} \text{Prime}(11), \text{Prime}(y)$
 Substitute y with 11
 $\underline{\underline{\text{Prime}(11), \text{Prime}(11)}}$,
 successfully unified.

e.g. $\underbrace{Q(a, g(x, a), f(y))}_{A_1}, \underbrace{Q(a, g(f(b), a), x)}_{A_2}$
 Substitute x with $f(b)$ $\boxed{f(b)/x}$

$Q(a, g(g(b), a), f(y))$, $Q(a, g(f(b), a), f(b))$
 Substitute (b/y) i.e. y is substituted with b

$Q(a, g(f(b), a), f(b))$, $Q(a, g(f(b), a), f(b))$
 UNIFIED SUCCESSFULLY

Resolution

- To do or not to do
- Decide with the help of facts

Resolution is a single inference rule which can efficiently operate on the conjunctive normal form (CNF) or clausal form.

Resolution method is an inference rule which is used in both

Propositional as well as First order Predicate logic in dif. ways.

This method is basically used for proving the satisfiability of a sentence. In resolution method, Proof of Refutation (contradiction) technique is used to prove the given statement.

Q Use propositional logic and apply resolution method to prove that the goal is derivable from the given knowledge base.

Solⁿ Let's construct propositions of the given sentences one by one :-

① Let, P : Humidity is high

Q : Sky is cloudy

It will be represented as $P \vee Q$

② Q : Sky is cloudy — from ①

Let R : It will rain

Representation :- $Q ? R$

③ P : Humidity is high — from ①

Let S : It is hot

$P ? S$

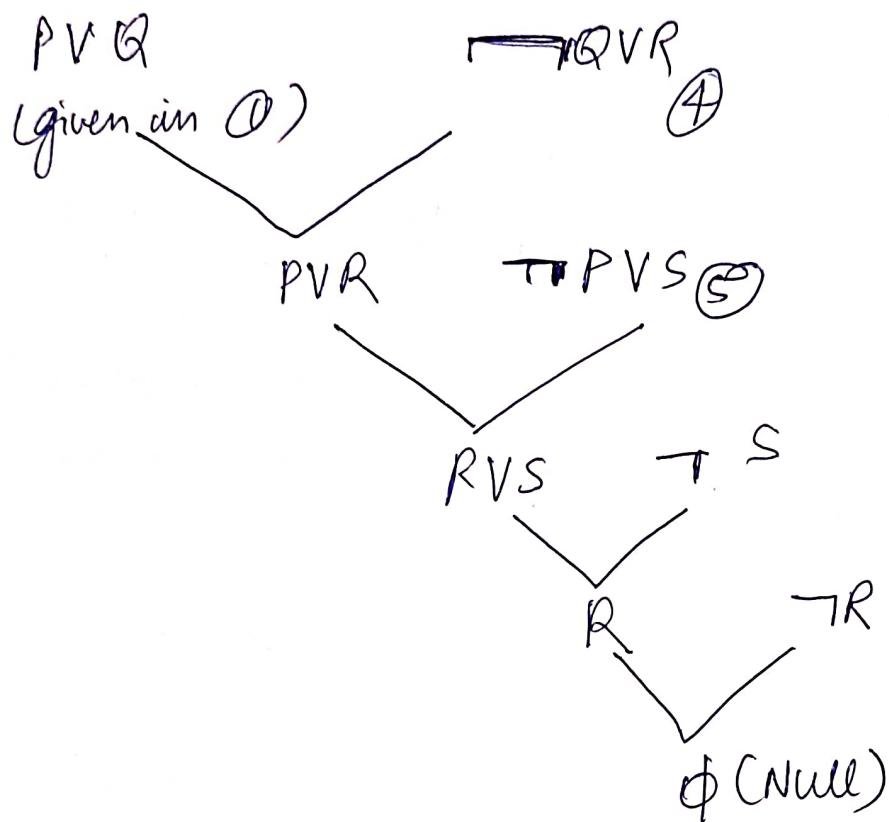
④ $\neg S$: It is not hot

Now, Apply Resolution method :-

In ②, $Q \vee R$ will be converted as $(\neg Q \vee R)$ — (4)

In ③, $P \vee S$ " " " " $(\neg P \vee S)$ — (5)

Negation of Goal ($\neg T R$) : It will not rain.



After applying proof by refutation (contradiction) on the goal, the problem is solved, and it has terminated with a null clause (ϕ). Hence, the goal is achieved. Thus, it is not raining.

- Rules
- ① Convert the given axiom into clausal form i.e. disjunction form
 - ② Apply and prove the given goal using negation rule
 - ③ Use those literals which are needed to prove.
 - ④ Solve the clauses together and achieve the goal.

Knowledge Rep" Using Semantic Nets :-

Graphical notation for representing knowledge in interconnected nodes pattern is Semantic Net. It is popular in AI & NLP since it represents knowledge or support reasoning. It can be an alternative of predicate logic sometimes.

- Nodes represent objects
 - Circle (physical)
 - ellipse (concept)
 - rectangle (situation)
- Arrows represent relation between objects. ↗ links / arrows
- Link labels ↗ specify relationships
- Also known as associative nets ↗ Nodes are associated.

Components

- Lexical Nodes, links, labels
- Structural Directed link or nodes
- Semantic Def'n related to links / nodes . Based on facts ↗ creation of new links
- Procedural ↗ Constructor Destructor ↗ removal of links.

We can store our knowledge in the form of a graph , with nodes representing objects in the world, and arrow representing relationships b/w those objects.

Eg.

Tom is a cat

Tom caught a bird

Tom is owned by John

Tom is ginger in colour

Cats like cream.

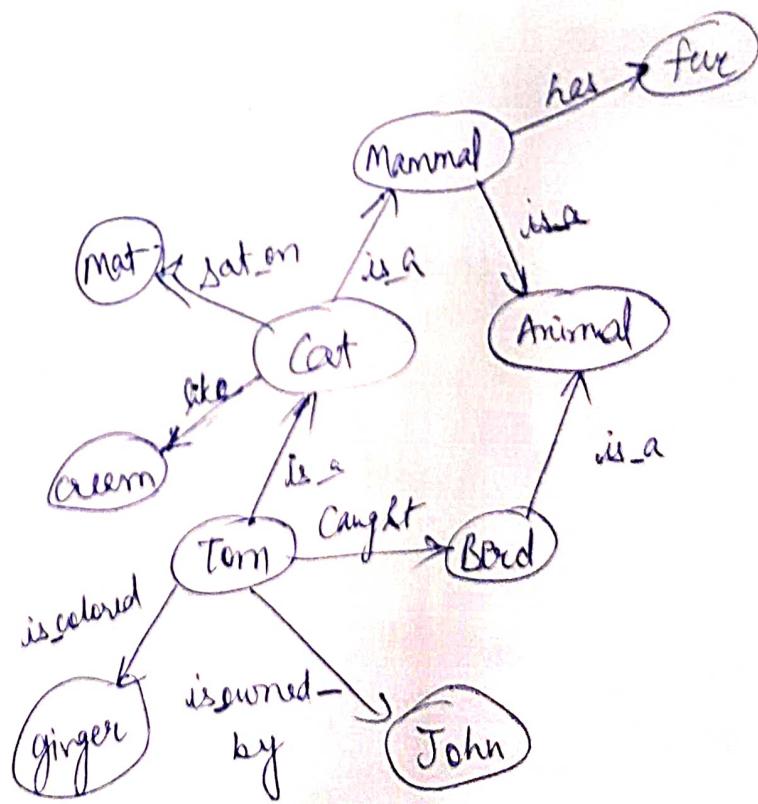
The cat sat on the mat

A cat is a mammal

A bird is an animal

All mammals are animals .

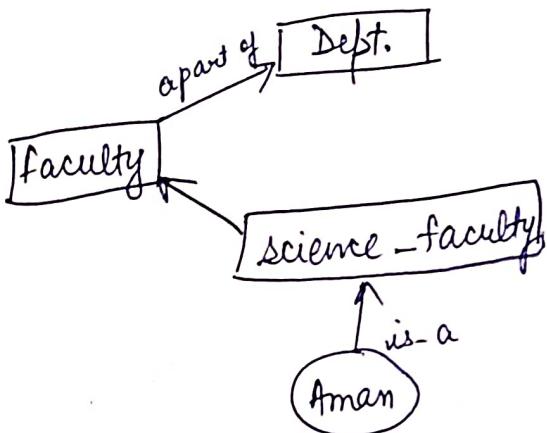
Mammals have fur.



Knowledge Rep" using FRAMES :-

Frame is a collection of attributes or slots & associated values that describe some real world entity. It uses the data structure (records) to represent the knowledge represented in semantic N/W.

Each frame represents the node in semantic N/W as a class or an instance & each relation as slot.



Attributes attached with each slot :-

- ① Instance :- Relates slot with class
- ② Definition :- Slot defn/value
- ③ Default :- Slot default value
- ④ Domain :- Slot elements domain
- ⑤ Range :- Specifies class of which elements

⑥ Range constraint :- logical exp $3 \leq i \leq 10$

⑦ To compute :- Value of the slot is to be computed.

⑧ Single valued :- func returns single value

⑨ Inverse :- Slot inverse used in reasoning.

⑩ Transfers-through :- Inheritance.

Reasoning actions that can be performed using frames :-

① Relating the definition :- is a, inverse links] propagation of defn to relate all info.

② Inheritance :- Inherited all values incl. default values of the slot

③ Legality of Value :- Checks the legality of slot value.

Range constraint

④ Consistency check :- Verifying slot value consistency before adding to the frame.

Domain

⑤ Maintaining consistency :- When one slot is updated its inverse should also be updated.

⑥ Computation of a Value of slot :- To compute transfers through

Frame is a record like structure which consists of a collection of attributes and its values to describe an entity in the world. Frames are the AI data structure which divides knowledge into substructures by representing stereotypes. It consists of a collection of slots & slot-type situations. It consists of any types & sizes.

These slots may be of any types and sizes which are called facets. Slots have names and values which enable us to put facets are features of frames.

constraints on the frames e.g. IF-NEEDED facts are called when data of any particular slot is needed. A frame is also known as slot-filter knowledge repⁿ in AI.

Applications :- NLP, Machine Vision

Slots	Filters
Title	AI
Genre	Computer Science
Author	Peter Norvig
Edition	Third Edition
Year	1996
Page	1152

Advantages

- ① Frame knowledge representation makes the programming easier by grouping the related data
- ② The frame repⁿ is comparably flexible & used by many apps in AI.
- ③ It is easy to add slots for new attr. & relations.
- ④ It is easy to include default data & to search for missing values.
- ⑤ Frame repⁿ is easy to visualize.

Disadvantages

- ① In frame system inference mechanism is not be easily processed.
- ② Inference mechanisms cannot be smoothly proceeded by frame representation.
- ③ Frame representation has a much generalized approach.

Uncertainty (Knowledge in AI)

Lack of exact infoⁿ or knowledge that helps us to find correct conclusion. (1)

Sources of Uncertainty :-

① Uncertain inputs

- Missing data
- Noisy data / irrelevant details

② Uncertain knowledge

- Multiple causes lead to multiple effects
- Incorrect or incomplete knowledge of causality in the domain.

③ Uncertain outputs

- Abduction, induction are uncertain.
- Default reasoning
- Incomplete deduction, inference

Uncertainty may be caused by problems with data such as:-

① Missing / unavailable data

② Unreliable / unambiguous data

③ Imprecise / inconsistent repⁿ of data

④ Guess based

Reasoning under Uncertainty :-

Probabilistic Reasoning :- It is a way of knowledge

representation where we apply the concept of probability to indicate the uncertainty in knowledge.

We combine probability theory with logic to handle uncertainty.

2 ways to solve problems:-

① Bayes's Rule

② Bayesian statistics / Networks

Bayes' Theorem

Acc. to cond'n probability,

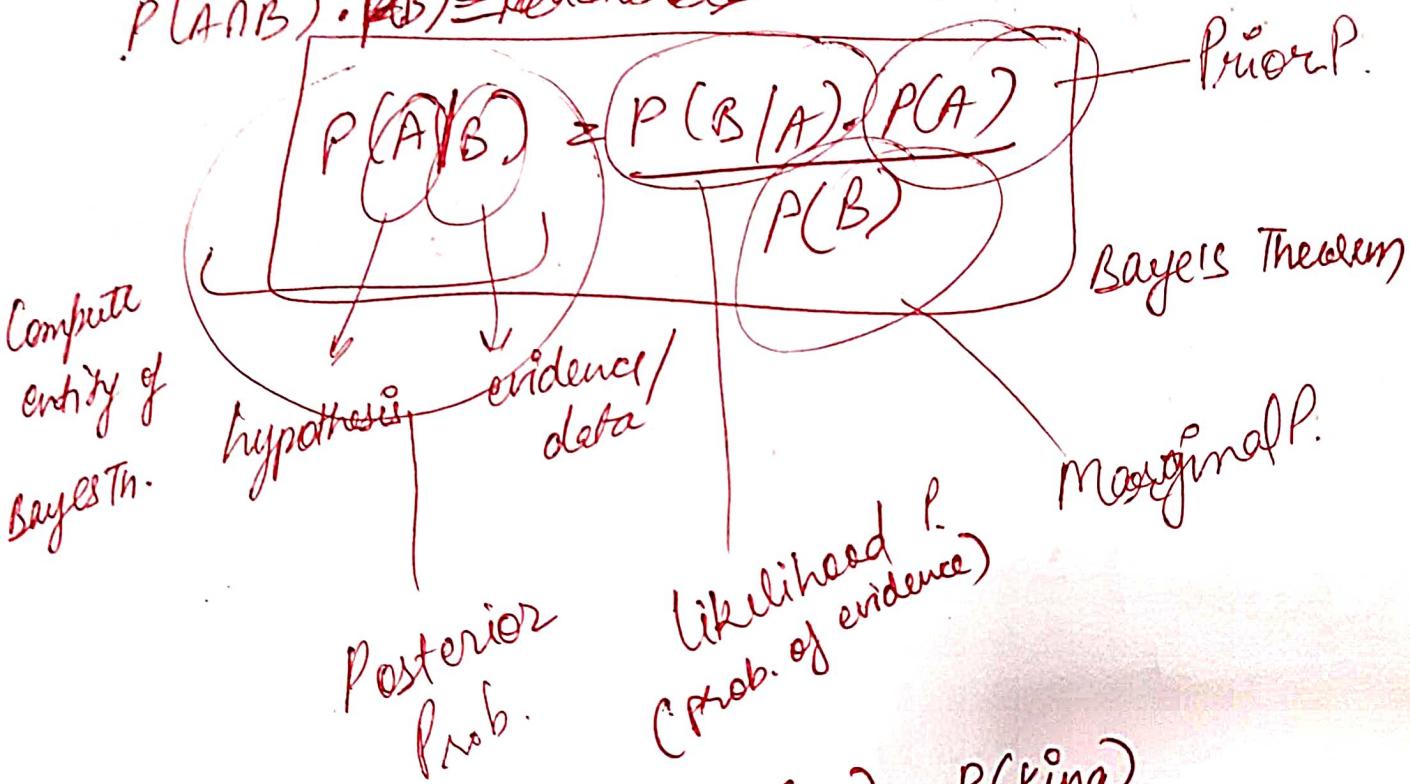
$$P(A|B) = \frac{P(A \cap B)}{P(B)}$$

(prob. of A given that B has already occurred)

given that

$$P(B|A) = \frac{P(B \cap A)}{P(A)}$$

~~$$P(A \cap B) \cdot P(B) = P(B|A) \cdot P(A)$$~~



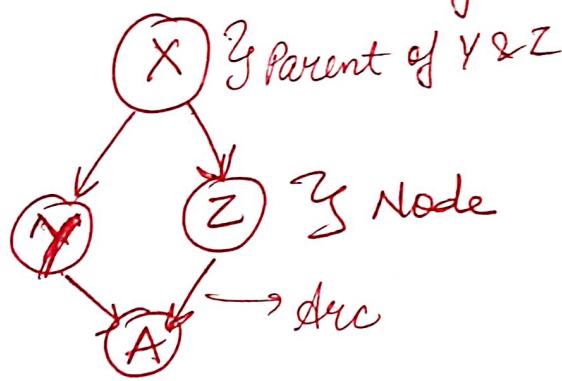
$$P(\text{King}|\text{face}) = \frac{P(\text{face}|\text{King}) \cdot P(\text{King})}{P(\text{face})}$$

$$\geq \frac{1 \cdot \frac{4}{52/13}}{\frac{12/52}{13}}$$

$$\approx \frac{1 \cdot \frac{1}{13}}{\frac{3}{13}} = \underline{\underline{\frac{1}{3}}} \text{ ans.}$$

Bayesian Belief Network in AI :- It defines probabilistic independencies and dependencies among the variables in the N/W.

- It is a probabilistic graphical model which represents a set of variables & their conditional dependencies using a directed acyclic graph.
- Built from Probability distribution
- Consists of
 - ① DAG
 - ② Table of conditional Probabilities
- Node corresponds to a random variable
 - Continuous
 - Discrete
- Arc (Directed arrows) : Represent causal relationship or conditional Probabilities among random variables.



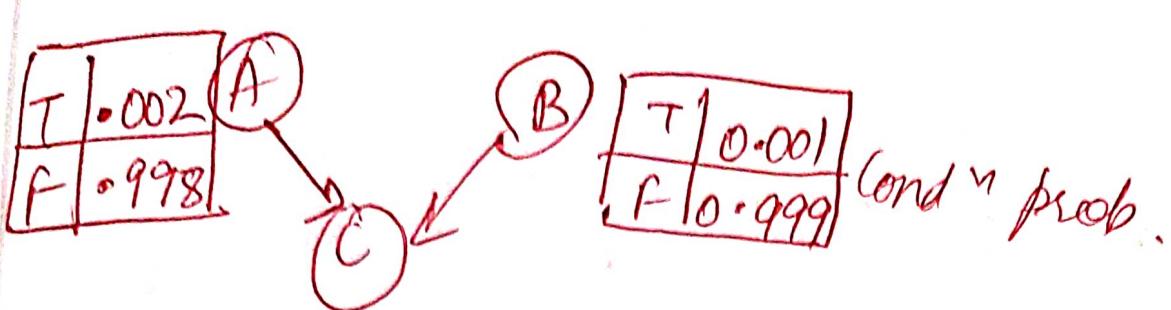
so, Bayesian Belief network shows dependency & independencies

Here, there is a direct influence of X on Y

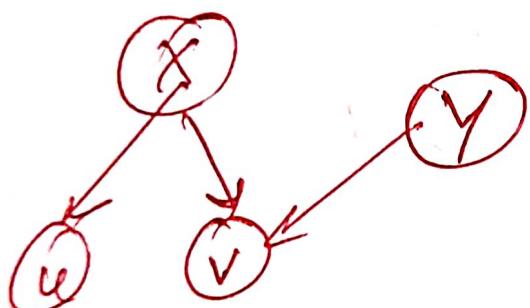
We will also create table :- Cond. Prob. of all nodes w.r.t. Parent nodes

To propagate belief in Bayesian N/W, initial "DAG" is converted into undirected in which the arcs can be used to transmit probabilities in direction of evidence.

e.g. \rightarrow



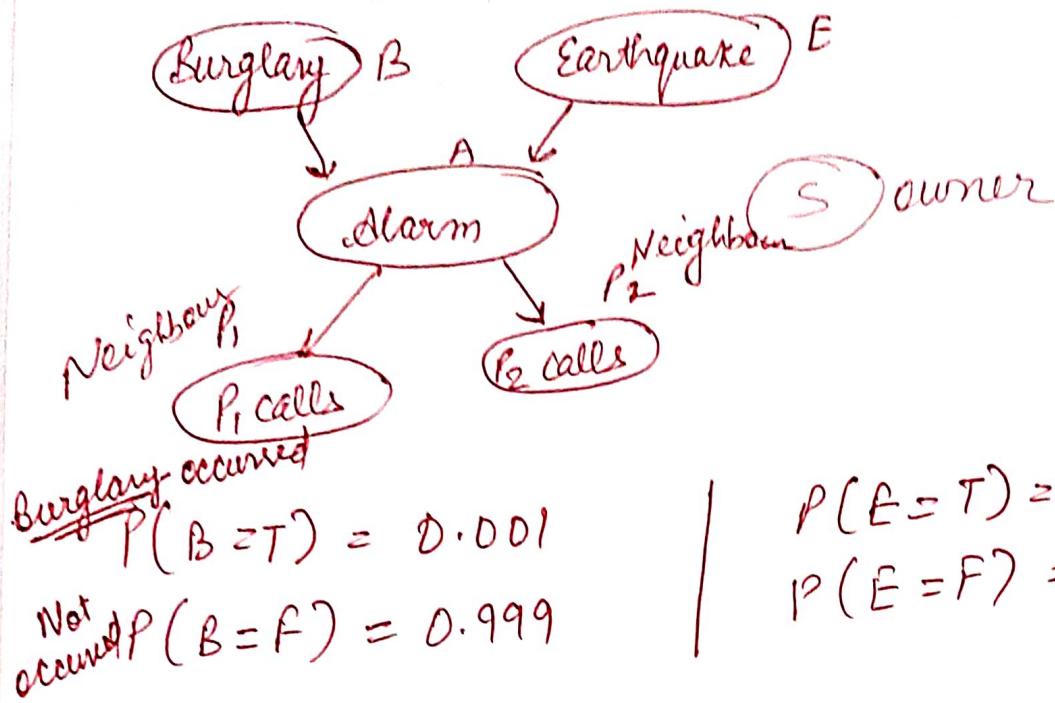
A	B	$P(C=T)$	$P(C=F)$
T	T	-	-
T	F	-	-
F	T	-	-
F	F	-	-



for correctness, there should not be a cycle

Example of Bayesian Belief Network :-

(3)



Shwani Rohilla . M.N.I.T Jaipur

		$P(A=T)$	$P(A=F)$	Observed values
		$P(A=T)$	$P(A=F)$	
		$P(A=T)$	$P(A=F)$	
B	E			
T	T	0.95	0.05	
T	F	0.99	0.01	
F	T	0.29	0.71	
F	F	0.001	0.999	

A	$P(P_1=T)$	$P(P_1=F)$
T	0.90	0.10
F	0.05	0.95

A	$P(P_2=T)$	$P(P_2=F)$
T	0.70	0.30
F	0.01	0.99

• $P(P_1, P_2, A, (\sim B, \sim E))$ Prob. of A w.r.t. no burg & no earthquake

$= P(P_1|A) \cdot P(P_2|A) \cdot P(A|\sim B, \sim E) \cdot P(\sim B) \cdot P(\sim E)$

$= 0.90 \times 0.70 \times 0.001 \times 0.999 \times 0.998$

$= 0.00062$

(A)

Probabilistic Reasoning

Probabilistic Reasoning over time

Forward & Backward Reasoning

Other uncertain techniques - Data Mining

Fuzzy logic

Dempster - Shafer theory

Probability

$0 \leq P(A) \leq 1 \rightarrow$ certainty

$$\xrightarrow{\text{uncertainty}} P(\sim A) + P(A) = 1$$

Conditional Probability :-

$$P(A|B) = \frac{P(A \cap B)}{P(B)}$$

$$P(B|A) = \frac{P(B \cap A)}{P(A)}$$

Probabilistic reasoning is a way of knowledge representations where we apply the concept of probability to indicate the uncertainty in knowledge. Here, we combine probability theory with logic to handle the uncertainty.

The sentences where we are not sure about their occurrence or certainty, we use Probabilistic reasoning like :-

e.g. Behaviour of someone in some situations .

Probabilistic reasoning over time In the real world, we observe a lot of phenomena which change over time. let us say we have a set of random variables which are changing over time. Some of them are observable and some are not. We need to model this uncertainty somehow by studying the past and the present & making useful predictions about the future.

Random variables :- A variable whose values depend on outcomes of a random phenomenon.

A random variable's possible values might represent the possible outcomes of a yet-to-be-performed experiment, or the possible outcomes of a past experiment whose already existing value is uncertain. They may also conceptually represent either the results of an "objectively" random process (such as rolling a die) or "subjective" randomness that results from incomplete knowledge of a quantity

Stochastic Process :- A collection of random variables $X = \{x_t : t \in T\}$ defined on a common probability space, taking values in a common set S (the state space), and indexed by a set T , often either \mathbb{N} or $[0, \infty]$ & thought of as time (discrete or continuous respectively)

Time and Uncertainty A time interval contains random variables, some observable & some not :-

X_t : denote the set of state variables at time t , unobservable

E_t : denote the set of observable evidence variables

e.g. Security guard with umbrella. For each day t , the set E_t contains a single evidence variable V_t (Umbrella) and the set X_t

- 3
- + Contains a single state variable R_t (Rain).
 - Evidence starts arriving at $t = 1$. Hence our umbrella world is represented by state variables R_0, R_1, \dots and evidence variables U_1, U_2, \dots

Markov Process

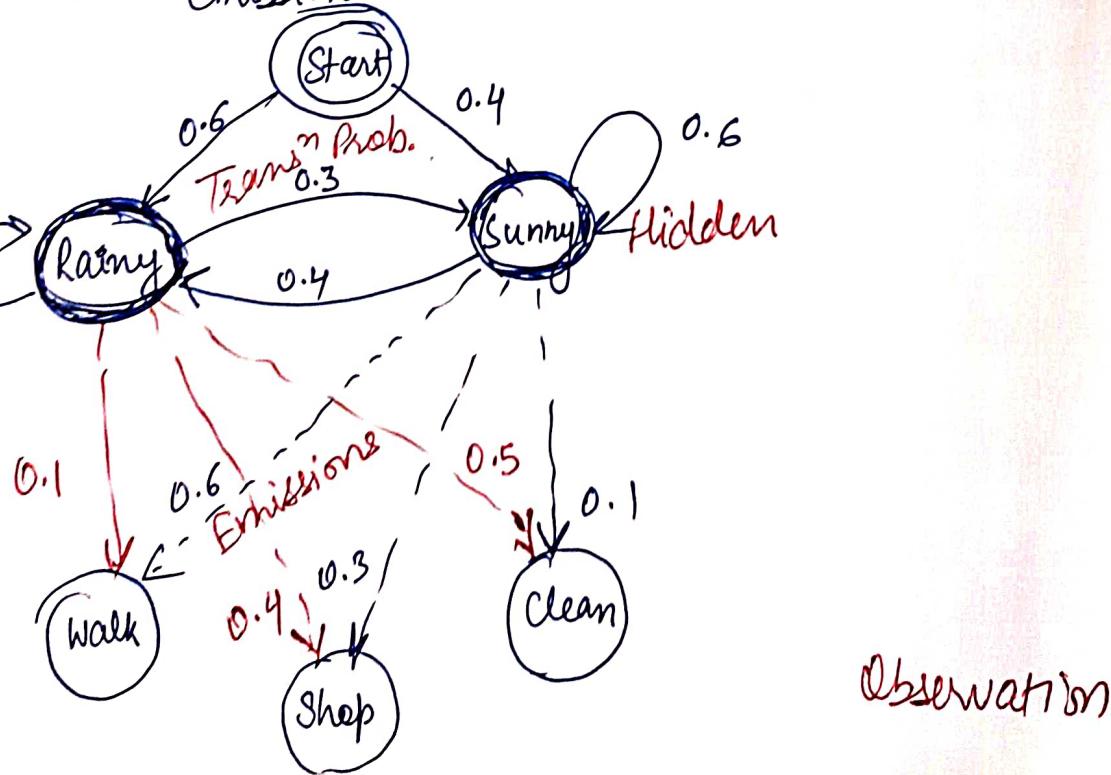
Hidden Markov Models generate models.

Markov Property: - ① It is memory less. It considers only one state. The future prediction relies on only present state (neither past nor future).

HMM is one of the most popular models where it is a statistical markov model in which the system being modelled is similar to be Markov process with unobserved (i.e. hidden) states.

Applications Reinforcement learning, speech recognition, gesture recognition, handwriting recognition, partial discharges, bioinformatics, stock price prediction.

Terminologies Hidden, observation, transition, probability, emissions.



Property

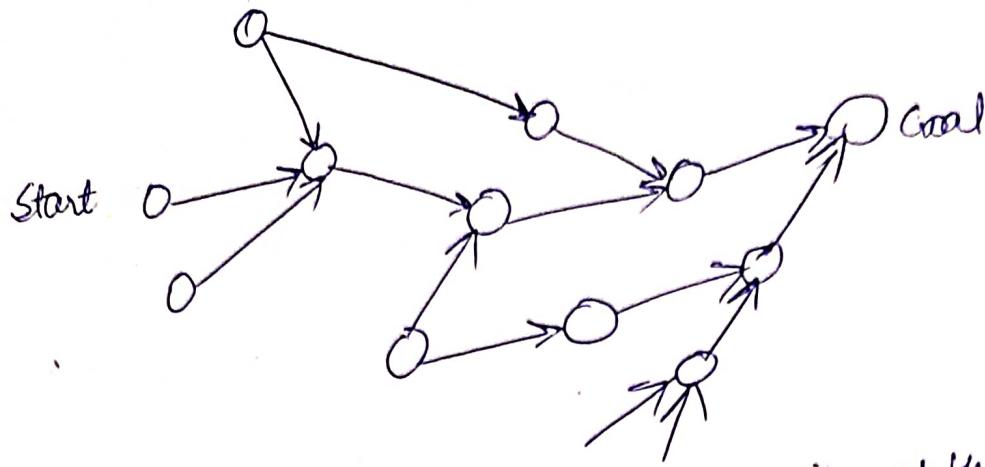
- ① Memory less
- ② Its future & past are independent i.e. prediction depends on current state.

Goal

The goal is to make a sequence of decisions, where, a particular decision may be influenced by earlier decisions.

forward and Backward Reasoning

Forward Reasoning :-



In forward reasoning, the left hand side of the rules are matched against the current state and right sides are used to generate the new state, until the goal is reached.

Reason forward from the initial state :-

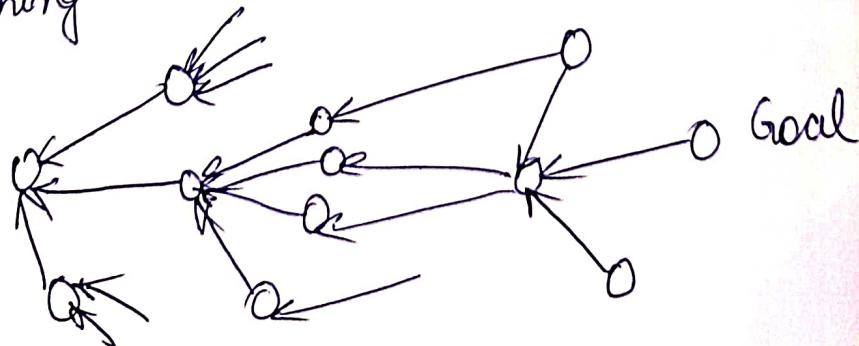
Step 1. Begin building a tree of move sequences by starting with the initial configuration at the root of the tree.

Step 2 Generate the next level of tree by finding all rules whose left hand side matches against the root node. The RHS is used to create new configurations.

Step 3 Generate the next level by considering the nodes in the previous level and applying it to all rules whose LHS match.

Backward Reasoning:-

It is Reasoning backward from the goal states:-



In Backward reasoning, RHS of the rules are matched against the current states & left sides are used to generate the new state.

Step 1 Begin building a tree of move sequences by starting with the goal node config. at the root of the tree.

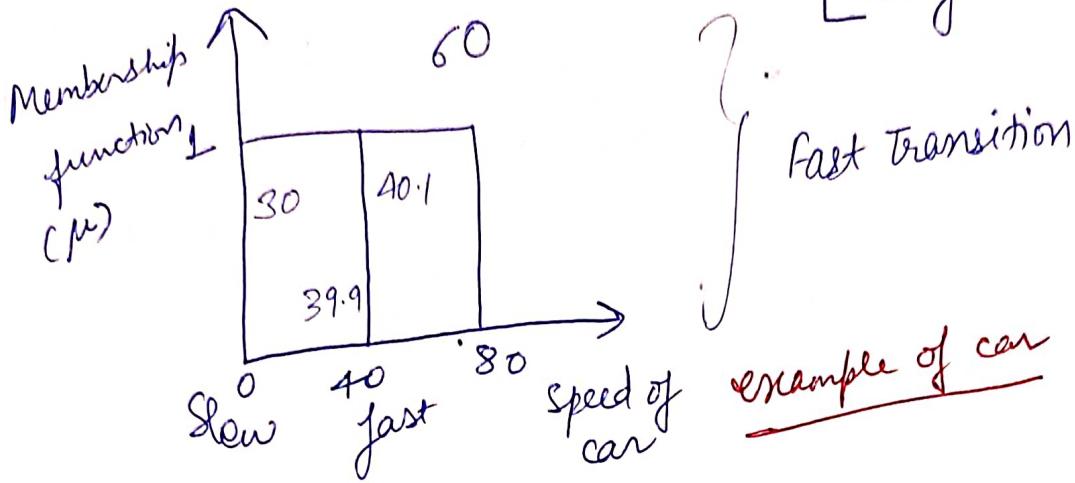
Step 2 Generate the next level of the tree by finding all rules whose RHS matches against the root node. The LHS is used to create new configurations.

Step 3 Generate the next level by considering the nodes in the prev. level and applying it to all rules whose RHS match it. Then use corresponding LHS to generate the new nodes. Continue until the node that matches the initial state is generated.

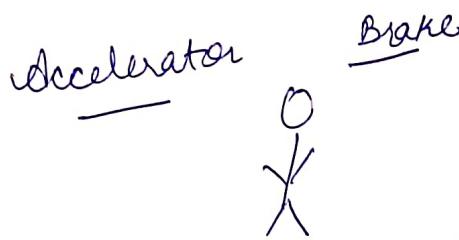
Fuzzy logic

In case of continuous values (not discrete), we need fuzzy logic. It represents uncertainty.

- It is represented by degree



example of car

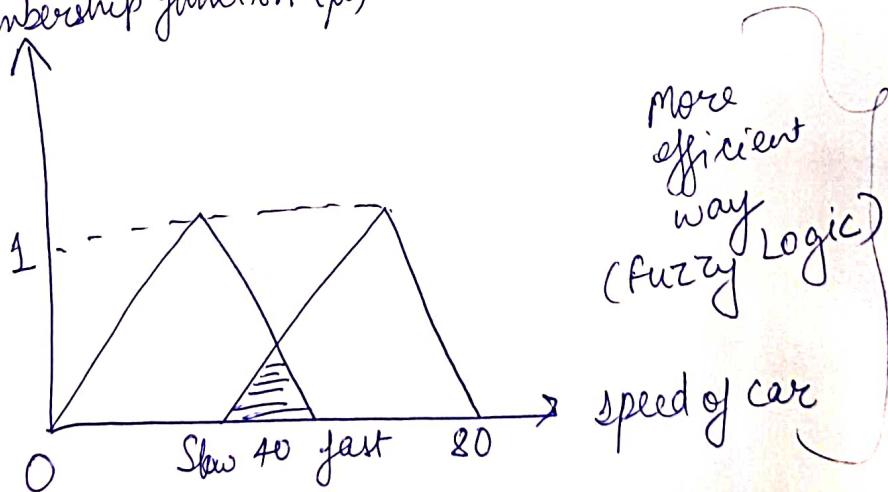


Knowledge Based Agent

[Fuzzy ~~takes~~ tells degree]

Fuzzy logic provides flexibility

membership function (μ)



"Check the degree of fastness" by this formula

$$\begin{cases} 0, & \text{if } \text{speed}(x) \leq 40 \\ \frac{\text{Speed}(x)-40}{10}, & \text{if } 40 < \text{Speed}(x) < 50 \\ 1, & \text{if } \text{speed}(x) \geq 50 \end{cases}$$

Data Mining is a branch of A.I. A.I. is supposed to improve upon the functions of the human brain, data mining does this by identifying patterns in the data that wouldn't otherwise be seen. Data mining is a process of using computers to identify hidden patterns in, and build models from large data sets. In order to utilize data mining the data must be clean & consistent & the data must reflect current & future trends.

e.g. Customer segmentation, Marketing & Promotion, Market Basket Analysis, Fraud Detection, Financial Modelling etc.

Advantages :- (Applications of Fuzzy logic)

- Control systems
 - (Kitchen appliances
 - (Car control systems)
 - Aerospace vehicle control systems
- Image Processing
- Decision - Making
- Route - Planning
- Testing for safety - critical systems .

e.g. Sam is tall (5 ft)

fairly if ($\text{speed} = 0$)

slow

else if ($\text{speed} = 1$)

fast

tall
fairly tall }
short

e.g. speed of car

0 - 0.25 - slowest

0.25 - 0.50 - slow

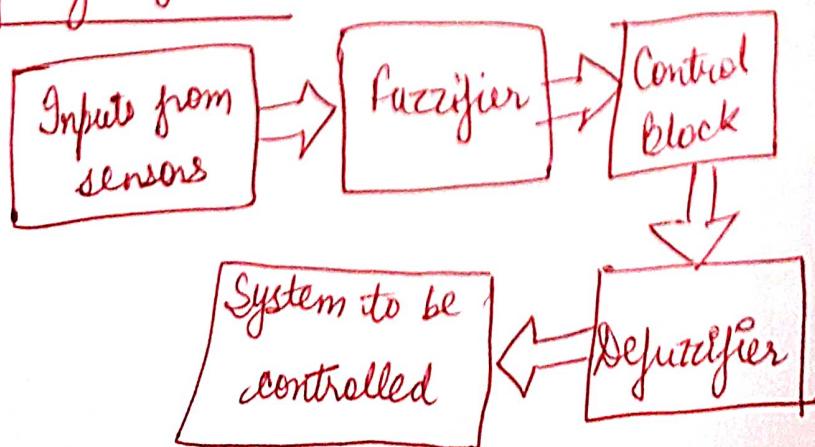
0.50 - 0.75 - fast

0.75 - 1.0 - fastest

e.g. Refrigerator

The fuzzy logic controller is used to maintain the inner temperature in spite of the environmental variations such as the outer temperature change or the volume change of the stored foods of the refrigerator.

Fuzzy logic system :-



Dempster-Shafer Theory / DST / Evidence Theory

Sequential framework for reasoning.

It is uncertain.

It can have a measure of Plausibility i.e. frequency

of correctness that it is true.

It fails when we work for hierarchical models.

Situation: A housewife finds a stain on her husband's shirt.

Her husband denies that it is a lipstick stain.

She knows that applying a little ethanol (C_2H_5OH) to a stain & softening it with washing up almost always removes lipstick stain. She also knows that this method hardly ever works on other stains.

She applies this method to the shirt & finds that it removes the stain. As ~~too~~ a result, she concludes that it was almost certainly a lipstick stain.

$$P(X|Y) = \frac{P(X) * P(Y|X)}{P(Y)}$$

$$P(\text{works} | \text{lipstick}) = 0.9 \quad (\text{suppose})$$

$$P(\text{works}) = 0.3 \quad (\text{suppose})$$

$$P(\text{lipstick} | \text{works}) = \frac{P(\text{works}) * P(\text{works} | \text{lipstick})}{P(\text{lipstick})}$$

$$\text{Also, } P(\text{lipstick}) = 0.25 \quad (\text{suppose})$$

$$\Rightarrow \frac{0.3 * 0.9}{0.25} = 0.75$$

$$P(\text{late} | \text{lipslick}) = 0.6$$

$$P(\text{late}) = 0.5$$

$$P(\text{lipslick} | \text{late}) = \frac{P(\text{lipslick}) * P(\text{late} | \text{lipslick})}{P(\text{late})}$$
$$= 0.75 \times ?$$

$$\text{may be} = 0.6$$

$$0.9$$

$$0.5$$

we may have many pieces of evidences & many conditions
probabilities.

So, to overcome this we have Dempster Shafer Theory

Arthur P. Dempster 1967

Glenn Shafer 1976

So, Narrowing down the set

{ strawberry stain, lipstick stain, blue ~~pink~~ stain }

$$= 0.8$$

\equiv
we can consider some points & draw some results through
reasoning without uncertainty

When we go through this theory we get some plausibility.

We have to fed all these info in knowledge Based Agents

This is knowledge Rep'n & Reasoning

Belief and Plausibility (Another example)

witness : " I am fairly sure that the car was either brown or black. Probably black, though it could have been brown. I could be wrong though."

Total mass = 1			
$m = 0.4$	$m = 0.2$	$m = 0.3$	$m = 0.1$
Car was black	Either black/brown	Car was brown	Neither

Belief

$$\text{Bel}(\text{Black}) = 0.4$$

$$\text{Bel}(\text{Brown}) = 0.3$$

$$\text{Bel}(\text{not Black}) = 0.3 + 0.1 = 0.4$$

$$\text{Bel}(\text{Not Brown}) = 0.5$$

$$\text{Plausibility} : \text{pl}(\text{Black}) = 0.4 + 0.2 \\ = 0.6$$

$$= 1 - \text{Bel}(\text{Not Black})$$

$$\text{pl}(\text{Brown}) = 0.2 + 0.3 \\ = 0.5$$

$$= 1 - \text{Bel}(\text{Not Brown})$$