UNIT-5

→ Uncertain Knowledge and Learning Uncertainty:

- Acting under uncertainty
- Basic Probability notation
- Inference using Full Joint Distributions
- Independence
- Baye's Rule and its Use

→ Probabilistic Reasoning:

- Representing Knowledge in an Uncertain Domain
- The Semantics of Bayesian Networks
- Efficient Representation of Conditional distributions
- Approximate inference in Bayesian Networks
- Relational and First-order Probability
- Other approaches to Uncertain Reasoning:
  - Dempster-Shafer theory

Unit-5

Real-world problems involve incomplete, noisy or uncertain info.

Uncertainty → not having complete information

→ AI may not know everything.

→ When AI does not have complete or accurate information.

ex: Robot does not know if the room is empty due to sensor error.

→ Uncertainty means lack of full knowledge.

→ In real life, AI systems often do not have perfect information.

→ So, AI must make decisions - even when data is incomplete or uncertain

Why does Uncertainty happen?

- incomplete knowledge.
- missing data
- Complex environments.

ex: A Robot doesn't know if the door is open or closed

→ AI uses mathematical models to handle with uncertainty :

- Probability
- Hidden Markov Models
- Bayesian Networks.

<u>Real - Life Applications</u>

→ Self-driving cars
→ Weather forecasting
→ Stock market prediction
→ Speech & voice recognition

* Baye's Rule

→ Baye's Rule is a formula used to calculate the Probabality.

Formulas

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

P(A) – Probabality of A.
P(B) – Probabality of B.
P(A|B) – Probabality of A given B.

→ It is a formula to update belief based on new evidence

Uses

→ AI decision making.
→ Spam email filtering,
→ Prediction under uncertainty,
→ AI, ML, NLP
→ Robotics
→ Weather prediction

Example:

- 30% Students study $\rightarrow$ $P(\text{Study}) = 0.3$
- If studied, Pass chance = 90%

$P(\text{Pass} | \text{Study}) = 0.9$

- If not studied, Pass chance = 30%

$P(\text{Pass} | \text{Notstudy}) = 0$

$\boxed{\text{find: } P(\text{Study} | \text{Pass})}$

$$P(\text{Study} | \text{Pass}) = \frac{(0.9)(0.3)}{(0.9 \times 0.3) + (0.3 \times 0.7)} = 0.5$$

*Basic Probability Notation

→ Pb measures how likely an event is to occur.

→ It ranges from 0 – 1.

Notation	Meaning
①. $P(A)$	Pb of event A
②. $P(A \cap B)$	Pb of both A and B
③. $P(A \cup B)$	Pb of A or B
④. $P(A \mid B)$	Pb of A given B
⑤. $P(A, B)$	Same as $P(A \cap B)$
⑥. Σ	Summation
⑦. Π	Product
⑧. $P(A_1, A_2, \ldots, A_n)$	Joint pb of multiple variables
⑨. $P(A')$ or $P(\sim A)$	Pb that A does not occur

* Full Joint Probability Distribution

→ A table that shows the Probabilities of all Possible combinations.

→ It represents the complete Probabilistic Knowledge.

Notation:

→ If we have variables $X_1, X_2, \ldots, X_n$, then full joint distribution is:

$P(X_1, X_2, \ldots X_n)$

→ It is a table showing all Possible combinations of variable values and their Probabilities.

→ Used to answer any pb question like:

- What is the chance of rain?
- What is the chance of rain if sprinkler is on?

Ex: Let Say we have 2 variables:

- Rain = Yes/NO
- Sprinkler - On/off

Rain	Sprinkler	pb
Yes	on	0.1
Yes	off	0.2
No	on	0.3
No	off	0.4

→ Add all Probabilities is equal to 1
($0.1+0.2+0.3+0.4=1$)

→ It helps AI to make decisions under uncertainty,

ex: Weather Prediction
- test result
- disease Prediction

⇒ For many Variables, table becomes too big.

⇒ So we use Bayesian Networks
- to make it smaller

* Representing Knowledge in an Uncertain Domain

→ Representing knowledge in AI
- when information is incomplete.

→ In real life, AI agents often lack complete or perfect information.

→ Uncertainty arises due to incomplete data, noisy sensors.

→ We use Probabilistic models to represent & knowledge in uncertain domain,

Causes of Uncertainty

- Incomplete data.
- Imperfect sensors
- Ambiguity (confusions)
- errors

Techniques to Represent Knowledge under uncertainty

→ Probability Theory

→ Bayesian Networks

→ Dempster - Shafer theory

→ Markov Models

→ Hidden Markov Models

* Bayesian Networks

→ Also called as "Belief Networks" or "Bayes Nets"

→ A Bayesian Network is a graphical model.

→ It is used to represent knowledge in an uncertain domain.

→ Each node = a variable

→ Each edge = relationship.

→ It uses Baye's theorem.

→ Bayesian Network = Graph + Probabilities.

Structure

- Graph type : Directed Acyclic Graph
- Components :
  - Nodes — Variables
  - Edges — relationship
  - Conditional Probability Table (CPT) — Show Pbs for each Variable

Ex:

We want to predict whether a cricket match will happen or not

- based on weather conditions and ground conditions.

Nodes

- Rain (Yes/No)
- GroundWet (Yes/No)
- MatchHappens (Yes/No)

Graph

~~Rain → GroundWet~~

Rain
↓
GroundWet
↓
MatchHappens.

- Rain affects GroundWet
- GroundWet affects whether MatchHappens.

$P(\text{Rain}) = 0.4$

$P(\text{GroundWet} \mid \text{Rain}) = 0.9$

$P(\text{Match} \mid \text{GroundWet}) = 0.2$ (if wet)
$\qquad 0.95$ (if dry)

* if it rains → ground gets wet → match cancell

* Dempster - Shafer theory

→ Dempster- Shafer theory is short for DST.

→ It can handle incomplete knowledge.

→ It is a theory of reasoning under uncertainty.

→ It is alternative to Probability theory.

→ It works with Partial knowledge.

Ex: If GPS and compass gave different readings

→ DST combines them to estimate most likely location.

→ It handles uncertain data.

→ It can express ignorance (lack of info).

Main terms

- Belief
- Plausibility

→ It is used to represent knowledge under uncertainty domain.

→ More flexible than traditional Pb.