UNIT-4

PROBABILISTIC GRAPHICAL MODEL

1) NAVIE BAYES ALGORITHM:

The Navie Bayes algorithm is a classification technically based on Bayes Theorem. It assumes that all features (attributes) are conditionally independent given the class label.

$$P(C/x) = \frac{P(x/C)\,P(C)}{P(x)}$$

where,

C → class

x → feature vector

Since P(x) is constant the decision is based on maximizing $P(x/C)\,P(C)$

Application:

- Spam detection
- Medical diagnosis
- Sentiment analysis

2) BAYESIAN BELEIF NETWORK: (BBN)

A Bayesian Belief Network (BBN) also known as a Bayesian Network, is a graphical

model that represents probabilistic relationships among a set of random variables.

It is represented as a directed Acyclic Graph (DAG).

- Nodes represent random variables.
- Edges represent conditional dependencies.
- Each node has a conditional probability Table (CPT) that quantifies the effect of parent class.

Example:

Consider Medical diagnosis network:

Node 1 : Flu

Node 2 : Fever

Node 3 : Cough

Here fever and cough depends on flu. The network compactly encodes those dependencies.

Advantages:

- Captures causal relationship.
- Handles incomplete data.
- Supports both inference (predict unknowns) and learning (update probabilities).

Application:

- Medical diagnosis (diseases + symptoms)
- Fault detection in engineering system.
- Decision support system.

3) Hidden Markov Model (HMM):

A hidden Markov Model (HMM) is a statistical model for systems that evolve over time but where underlying states are hidden. Instead, we observe outcomes generated, probabilistic from the hidden states.

Components:

a) Hidden states (S)

b) Observation (O)

c) Transition Probabilities (A)

d) Emission probabilities (B)

e) Initial state distribution (π)

Key problems solved by HMM:

* Evaluation: Compute probability of observation sequence given model.
* Decoding: Determine most likely sequence of hidden states (Viterbi algorithm)
* Learning: Estimate parameters.

Application:

* Speech recognition
* Natural Language Processing
* Bio Informatics.

4. BAYESIAN INFERENCE:

Bayesian Inference is a method of statistical inference where probability is used to represent uncertainity about parameters. Unlike frequentist methods, Bayesian methods update beliefs based on new evidence.

$$P(H|D) = \frac{P(D|H) \cdot P(H)}{P(D)}$$

where,

H → Hypothesis

D → observed data

Advantages:

* Incorporates prior knowledge.
* Naturally handles uncertainity.
* Produces full probabilities distributions.

PROBLEM BASED ON NAIVE BAYES:

Problem:

A spam filters uses the naive Bayes algorithm. Consider the word "offer" appearing in emails. P(spam) = 0.4, P(not spam) = 0.6, P(offer | spam) = 0.8, P(offer | not spam) = 0.2.

If an email contains the word "offer" classify it as spam or not spam.

Solution:

$$P(\text{spam}/\text{offer}) = \frac{P(\text{offer}/\text{Spam})\,P(\text{spam})}{P(\text{offer})}$$

$$P(\text{offer}) = P(\text{offer}/\text{spam}) + P(\text{offer}/\text{not spam})\,P(\text{not spam})$$

$= (0.8)(0.4) + (0.2)(0.6)$

$= 0.32 + 0.12$

$= 0.44$

Now,

$P(\text{spam} / \text{offer}) = \frac{0.8 \times 0.4}{0.44} = 0.727$

$P(\text{NOT spam} / \text{offer}) = \frac{0.2 \times 0.6}{0.44} = 0.273$

Hence the email is classified as "spam".