Unit - 4 Probablistic Giraphical Models

1) NAIVE BAYES ALGORITHM:

The Naive Bayes algorithm is a classification technique 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).

Applications:

* 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 probablistic relationships among a set of random variables.

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

* Nodes represent random variables.
* Edges represents conditional dependencies.
* Each node has a conditional probablity Table (CPT) that quantifies the effect of parent nodes.

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 these dependencies.

Advantages:

* Captures casual relationships.
* Handles incomplete data.
* Supports both inference (predict unknowns) and learning (update probabilities)

Applications:

* Medical diagnosis (diseases & symptoms)
* Fault detection in engineering systems.
* 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 ~~ca~~ states.

Components:

a) Hidden states (S)
b) Observations (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 statical 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 probability distributions.

PROBLEM BASED ON NAIVE BAYES :

Problem :

A spam filter uses the Naive Bayes algorithm. Consider the word "Offer" appearing in emails.

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

$P(\text{Not spam}) = 0.6$

$P(\text{Offer} \mid \text{spam}) = 0.8$

$P(\text{Offer} \mid \text{not spam}) = 0.2$

If an email ~~class~~ contains the word "Offer", classify it as Spam or Not Spam.

Solution :

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

(6)

$$P(\text{Offer}) = P(\text{Offer} \mid \text{Spam}) + P(\text{Offer} \mid \text{NotSpam}) P(\text{Not Spam})$$

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

$$= 0.32 + 0.12$$

$$= 0.44$$

Now,

$$P(\text{Spam} \mid \text{Offer}) = \frac{0.8 \times 0.4}{0.44} = 0.727$$

$$P(\text{NotSpam} \mid \text{Offer}) = \frac{0.2 \times 0.6}{0.44} = 0.273$$

Hence the email is classified as "Spam".