35. Naive Bayes

- These are classification algorithm which work on **conditional probabilty basis**
- Naive Bayes is a classification algorithm based on Bayes' theorem.
- which is a probability theory that describes the probability of an event, based on prior knowledge of conditions that might be related to the event
- **Naive**: It is called Naive b/c it assumes that the occurrence of a certain feature is independent of the occurrence of other features.
- **Bayes**: It is called Bayes b/c it depends on the principle of Bayes' Theorem.

Conditional Probability

$$\mathrm{P(E)} = \frac{\text{favourable outcome(s)}}{\text{total outcomes}}$$

0 <= P(E) >= 1

Example: A bag contains 3 red balls and 2 blue balls.

$$\mathrm{P(red\ balls)} = \frac{3}{3+2} = 0.60$$

Conditional Probability has 2 more types:

1. Indepedent Probability
2. Depdent Probability

1. **Independent Probability**

- Rolling a dice can have following events: {1,2,3,4,5,6}
- For single event the probability will be 1/6
- The preceding event and followng event both are not dependents on each other

2. **Dependent Probability**

- It is also called **Conditional Probability**
- In above balls example, the probability of P(red balls) = 3/5.
- But condition is that when you take the ball out, then do not put it back to the bag.
- so if we have taken one red ball from the bag, then there will be 2 red balls left and 4 total balls,
- In such circumstance, probability of blue ball is 2/4
- Hence the probabily of blue ball is depending upon the probabilty of red balls

- so we can express this as:

$$P(\text{Blue Balls}) = P(\frac{\text{Blue Balls}}{\text{Red Balls}}) = P(\frac{B}{R})$$

Also can be written as:

$$P(\text{R or B}) = P(R) * P(\frac{B}{R})$$

OR

$$P(\text{R or B}) = P(B/R) * P(R)$$

Bayes' Theorem:

$$P(\text{A n B}) = P(B/A) * P(A)$$

as

$$P(\text{A n B}) = P(\text{B n A})$$

so

$$P(\text{B n A}) = P(A/B) * P(B)$$

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As

$$P(\text{A n B}) = P(\text{B n A})$$

So

$$P(B/A) * P(A) = P(A/B) * P(B)$$

To find P(A/B)

$$P(A/B) = \frac{P(B/A) * P(A)}{P(B)}$$

The above forumula is called **Bayes' Theorem**

- This formula states that when event B is occured, then what are chances of event A to come

Bayes' Theorem

- **Bayes' Theorem** is also known as Bayes' Rule or Bayes' law.
- which is used to determine the probability of a hypothesis with prior knowledge.

- It depends on the conditional probability.
- It is expressed as:

$$P(A/B) = \frac{P(B/A) * P(A)}{P(B)}$$

Where:

- **P(A/B) is Posterior Probability**: Probability of hypothesis A on the observed event B.
- **P(B/A) is Likelihood Probability**: Probability of hypothesis B when event A is occurring. Probability of the evidence given that the probability of a hypothesis is true.
- **P(A) is Prior Probability**: Probability of hypothesis before obeserving the evidence.
- **P(B) is Marginal Probability**: Probability of evidence.

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Types of Naive Bayes Model

There are three types of Naive Bayes Model:

1. Gaussian
2. Multinomial
3. Bernoulli

1. **Gaussian Naive Bayes:**

- Assumes that continuous features follow a Gaussian (normal) distribution
- Suitable for features that are continuous and have a normal distribution

2. **Bernoulli Naive Bayes:**

- Assumes that features are binary (Boolean) variables
- Suitable for data that can be represented as binary features, such as document classification problems where each term is either present or absent

3. **Multinomial Naive Bayes:**

- Assumes that features follow a multinomial distribution
- Typically used for discrete data, such as text data, where each features represents the frequency of a term.

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