Naive Bayes Algorithm

- Naive Bayes is a powerful algorithm used for classification tasks in machine learning.
- It is based on applying Bayes' theorem with a crucial assumption of strong independence between features.
- The algorithm leverages Bayes' theorem to make predictions.
- Bayes' theorem calculates the probability of a hypothesis based on prior probabilities.
- Naïve Bayes models are also known as simple Bayes or independent Bayes.

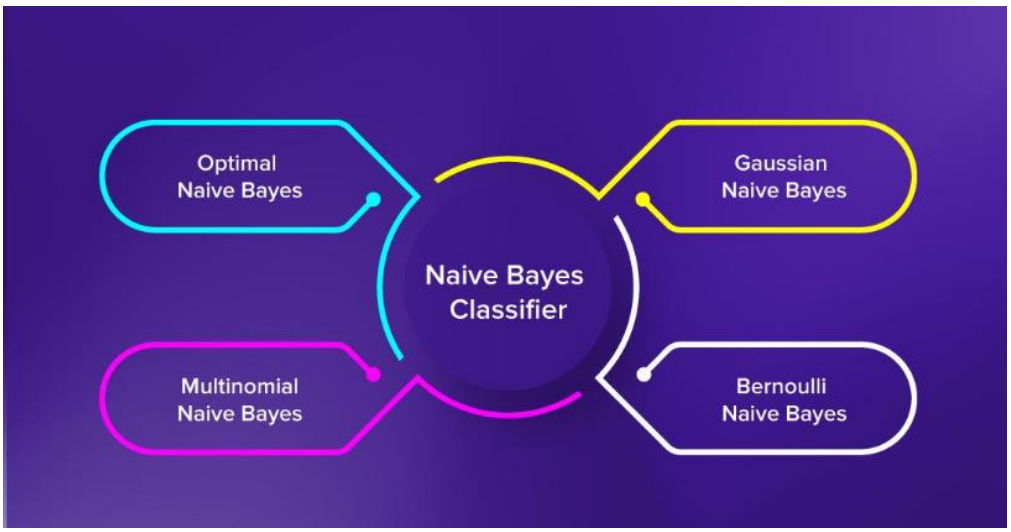
Naive Bayes algorithm intuition

- Naïve Bayes Classifier uses the Bayes' theorem to predict membership probabilities for each class such as the probability that given record or data point belongs to a particular class.
- The class with the highest probability is considered as the most likely class.
- This is also known as the **Maximum A Posteriori (MAP)**.

$$P(A \mid B) = \frac{P(B \mid A)\, P(A)}{P(B)}$$

A,B	= events
$P(A \mid B)$	= probability of A given B is true
$P(B \mid A)$	= probability of B given A is true
$P(A), P(B)$	= the probabilities of A and B

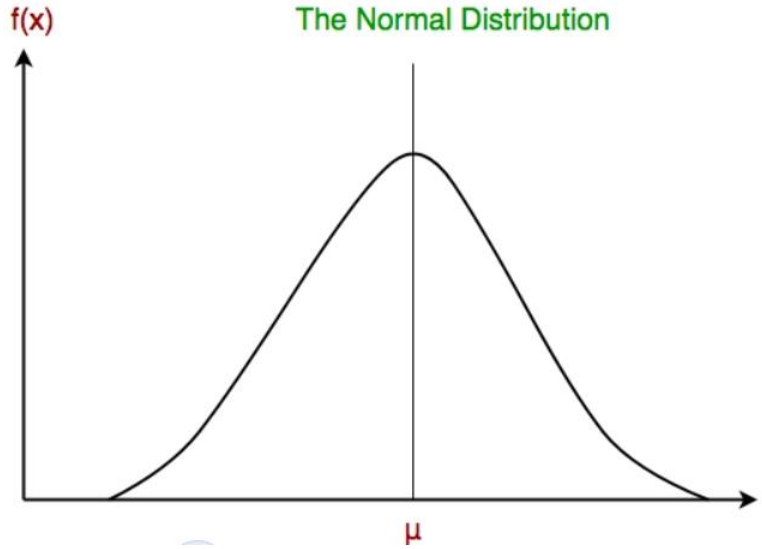
Types of Naive Bayes algorithm



1. Gaussian Naïve Bayes algorithm

- When we have continuous attribute values, we made an assumption that the values associated with each class are distributed according to Gaussian or Normal distribution.
- Machine learning algorithm for classification.
- Probabilistic approach based on Bayes' theorem.
- "Naive" due to strong independence assumption between features.
- Suitable for problems with continuous features.
- Estimate probability distribution of each feature for each class:
- Calculate mean and standard deviation of each feature for each class.
- Represent mean value and variability of the feature within a class.
- Calculate probability of each class label given the observed features.
- For example,Training data with continuous attribute x
- Segmented data by class
  - Mean **μi**
  - variance **σi** of attribute **x** for each class i
  - Observation value **xi**

$$p(x_i|y_j) = \frac{1}{\sqrt{2\pi\sigma_j^2}} e^{-\frac{(x_i-\mu_j)^2}{2\sigma_j^2}}$$



2.Multinomial Naïve Bayes algorithm

- With a Multinomial Naïve Bayes model, samples (feature vectors) represent the frequencies with which certain events have been generated by a multinomial (p1, . . . ,pn) where pi is the probability that event i occurs.
- Multinomial Naïve Bayes algorithm is preferred to use on data that is multinomially distributed.
- It is one of the standard algorithms which is used in text categorization classification.

$$P(X_1 = x_1 \cap X_2 = x_2 \cap \ldots \cap X_k = x_k) = \frac{n!}{\prod_i x_i!} \prod_i {p_i}^{x_i}$$

3. Bernoulli Naive Bayes

- Classification algorithm based on Bayes' theorem.
- Predicts probability of a sample belonging to a specific class.
- Used for binary classification problems (target variable: 0 or 1).
- Independence of features: Each feature independent of all others.
- Bernoulli distribution: Each feature has two possible values (0 or 1) with equal probability across samples.

The mathematical formula for Bernoulli Naive Bayes is as follows:

P(y|x) = P(y) * ∏ P(xi|y)

Where:

- P(y|x) is the posterior probability of class y given the features x
- P(y) is the prior probability of class y
- P(xi|y) is the likelihood of feature i given class y
- ∏ is the product symbol

Advantages of Naive Bayes Classifier

- Naive Bayes is one of the most fast-moving and effortless Machine Learning algorithms to predict the class of a dataset.
- It can manage to perform Binary as well as Multi-class Classifications.
- It is best suited for multi-class predictions as compared to any other algorithm.
- The most popular practical implementation of this classifier is for text classification problems.

Disadvantages of Naive Bayes Classifier

- The data may not always be independent of each other.
- This algorithm can not be used for an imbalanced dataset.
- When we encounter a response vector in the test data for a particular class absent in the training data, we might end up with zero class probabilities; this is known as the Zero probability problem.

Applications of Naive Bayes Classifier

- Spam filtration
- Text classification
- Sentiment analysis
- Recommendation System
- Multi-class prediction