

# Naïve Bayes

Naïve Bayes is a **probabilistic classifier** based on **Bayes' Theorem**. It assumes that features are **conditionally independent**, which is why it is called "naïve." Despite this assumption, it performs well in real-world applications like **spam detection, sentiment analysis, and document classification**.

## Types of Naïve Bayes Classifiers

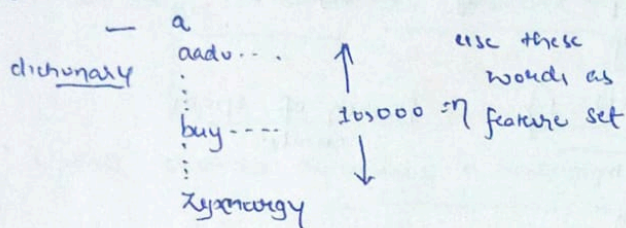
1. **Gaussian Naïve Bayes**: Assumes features follow a normal distribution.
2. **Multinomial Naïve Bayes**: Used for **text classification** (e.g., spam filtering, sentiment analysis).
3. **Bernoulli Naïve Bayes**: Suitable for **binary feature values** (e.g., word presence/absence in text).

## Day-7 Naive Bayes:

The Naive Bayes classifier is a supervised machine learning algorithm that is used for classification task such as text classification. They use principles of probability to perform classification tasks.

### Naive Bayes:

feature vector  $x$ ?



$$x = \begin{bmatrix} 1 \\ 0 \\ 0 \\ \vdots \\ 1 \\ \vdots \\ 0 \end{bmatrix}$$

$$x \in \{0, 1\}^n$$

$$x_i = \begin{cases} 1 & \text{(word } i \text{ appears in e-mail)} \\ 0 & \text{otherwise} \end{cases}$$

Model of  $p(x/y)$ ,  $p(y)$

$\approx 10,000$  possible value of  $x$

$$\approx 10,000 - 1$$

we are going to Assume

$x_i$ 's are conditionally independent given  $y$ .

$$p(x_1, \dots, x_{10000} | y) = p(x_1 | y) p(x_2 | x_1, y) p(x_3 | x_1, x_2, y) \dots$$

assume:

$$= p(x_1 | y) p(x_2 | y) p(x_3 | y) \dots p(x_{10000} | y)$$

sometimes called naive assumption

Not true in mathematical sense

$$= \prod_{i=1}^n p(x_i | y)$$



Parameters:

$$\phi_{j|y=1} = p(x_j=1 | y=1)$$

$$\phi_{j|y=0} = p(x_j=1 | y=0)$$

$$\phi_y = p(y=1)$$

Joint likelihood

$$\mathcal{L}(\phi_y, \phi_{j|y}) = \prod_{i=1}^n p(x^{(i)}, y^{(i)}; \phi_y, \phi_{j|y})$$

MLR:

After solving

$$\phi_y = \frac{\sum_{i=1}^n 1\{y^{(i)}=1\}}{n} \quad \text{fraction of specm emails}$$

$$\phi_{j|y=1} = \frac{\sum_{i=1}^n 1\{x_j=1, y^{(i)}=1\}}{\sum_{i=1}^n 1\{y^{(i)}=1\}}$$

Indicator function notation

$$\sum_{i=1}^n 1\{y^{(i)}=1\}$$