

Probabilistic Learning – Classification Using Naive Bayes

- Naïve Bayes algorithm is a supervised learning algorithm, which is based on **Bayes theorem** and used for solving classification problems.
- It is mainly used in *text classification* that includes a high-dimensional training dataset.
- Naïve Bayes Classifier is one of the simple and most effective Classification algorithms which helps in building the fast machine learning models that can make quick predictions.
- **It is a probabilistic classifier, which means it predicts on the basis of the probability of an object.**

Conditional Probability and bayes theorem

Conditional probability is a measure of the probability of an event occurring, given that another event (by assumption, presumption, assertion or evidence) has already occurred.

If the event of interest is A and the event B is known or assumed to have occurred, "the conditional probability of A given B", or "the probability of A under the condition B", is usually written as $P(A|B)$

$$P(A | B) = \frac{P(A \cap B)}{P(B)}.$$

By definition, $P(A \cap B) = P(A|B) * P(B)$

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.

The formula for Bayes' theorem is given 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.

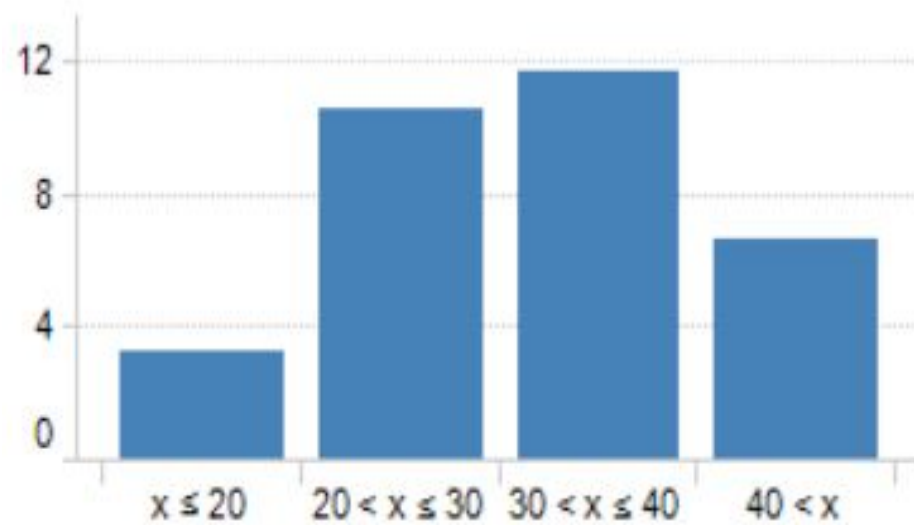
$P(B|A)$ is Likelihood probability: Probability of the evidence given that the probability of a hypothesis is true.

$P(A)$ is Prior Probability: Probability of hypothesis before observing the evidence.

$P(B)$ is Marginal Probability: Probability of Evidence.

Naïve bayes algorithm does not work directly with numeric data.

One easy and effective solution is to discretize numeric features, which simply means that the numbers are put into categories known as bins. For this reason, discretization is also sometimes called binning.



Binned Age ▼ + ▼

Example

- Example: Play Tennis

PlayTennis: training examples

Day	Outlook	Temperature	Humidity	Wind	PlayTennis
D1	Sunny	Hot	High	Weak	No
D2	Sunny	Hot	High	Strong	No
D3	Overcast	Hot	High	Weak	Yes
D4	Rain	Mild	High	Weak	Yes
D5	Rain	Cool	Normal	Weak	Yes
D6	Rain	Cool	Normal	Strong	No
D7	Overcast	Cool	Normal	Strong	Yes
D8	Sunny	Mild	High	Weak	No
D9	Sunny	Cool	Normal	Weak	Yes
D10	Rain	Mild	Normal	Weak	Yes
D11	Sunny	Mild	Normal	Strong	Yes
D12	Overcast	Mild	High	Strong	Yes
D13	Overcast	Hot	Normal	Weak	Yes
D14	Rain	Mild	High	Strong	No

$$P(\text{Play}=\text{Yes}) = 9/14$$

$$P(\text{Play}=\text{No}) = 5/14$$

PlayTennis: training examples

Day	Outlook	Temperature	Humidity	Wind	PlayTennis
D1	Sunny	Hot	High	Weak	No
D2	Sunny	Hot	High	Strong	No
D3	Overcast	Hot	High	Weak	Yes
D4	Rain	Mild	High	Weak	Yes
D5	Rain	Cool	Normal	Weak	Yes
D6	Rain	Cool	Normal	Strong	No
D7	Overcast	Cool	Normal	Strong	Yes
D8	Sunny	Mild	High	Weak	No
D9	Sunny	Cool	Normal	Weak	Yes
D10	Rain	Mild	Normal	Weak	Yes
D11	Sunny	Mild	Normal	Strong	Yes
D12	Overcast	Mild	High	Strong	Yes
D13	Overcast	Hot	Normal	Weak	Yes
D14	Rain	Mild	High	Strong	No

Outlook	Play=Yes	Play=No
<i>Sunny</i>	2/9	3/5
<i>Overcast</i>	4/9	0/5
<i>Rain</i>	3/9	2/5

Temperature	Play=Yes	Play=No
<i>Hot</i>	2/9	2/5
<i>Mild</i>	4/9	2/5
<i>Cool</i>	3/9	1/5

PlayTennis: training examples

Day	Outlook	Temperature	Humidity	Wind	PlayTennis
D1	Sunny	Hot	High	Weak	No
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D9	Sunny	Cool	Normal	Weak	Yes
D10	Rain	Mild	Normal	Weak	Yes
D11	Sunny	Mild	Normal	Strong	Yes
D12	Overcast	Mild	High	Strong	Yes
D13	Overcast	Hot	Normal	Weak	Yes
D14	Rain	Mild	High	Strong	No

Humidity	Play=Yes	Play=No
<i>High</i>	3/9	4/5
<i>Normal</i>	6/9	1/5

Wind	Play=Yes	Play=No
<i>Strong</i>	3/9	3/5
<i>Weak</i>	6/9	2/5

Example

- Test Phase

- Given a new instance,

$\mathbf{x}' = (\text{Outlook}=\text{Sunny}, \text{Temperature}=\text{Cool}, \text{Humidity}=\text{High}, \text{Wind}=\text{Strong})$

- Look up tables

$$P(\text{Outlook}=\text{Sunny} \mid \text{Play}=\text{Yes}) = 2/9$$

$$P(\text{Temperature}=\text{Cool} \mid \text{Play}=\text{Yes}) = 3/9$$

$$P(\text{Humidity}=\text{High} \mid \text{Play}=\text{Yes}) = 3/9$$

$$P(\text{Wind}=\text{Strong} \mid \text{Play}=\text{Yes}) = 3/9$$

$$P(\text{Play}=\text{Yes}) = 9/14$$

$$P(\text{Outlook}=\text{Sunny} \mid \text{Play}=\text{No}) = 3/5$$

$$P(\text{Temperature}=\text{Cool} \mid \text{Play}=\text{No}) = 1/5$$

$$P(\text{Humidity}=\text{High} \mid \text{Play}=\text{No}) = 4/5$$

$$P(\text{Wind}=\text{Strong} \mid \text{Play}=\text{No}) = 3/5$$

$$P(\text{Play}=\text{No}) = 5/14$$

$$P(\text{Yes} \mid \mathbf{x}'): [P(\text{Sunny} \mid \text{Yes})P(\text{Cool} \mid \text{Yes})P(\text{High} \mid \text{Yes})P(\text{Strong} \mid \text{Yes})]P(\text{Play}=\text{Yes}) = 0.0053$$

$$P(\text{No} \mid \mathbf{x}'): [P(\text{Sunny} \mid \text{No})P(\text{Cool} \mid \text{No})P(\text{High} \mid \text{No})P(\text{Strong} \mid \text{No})]P(\text{Play}=\text{No}) = 0.0206$$

Given the fact $P(\text{Yes} \mid \mathbf{x}') < P(\text{No} \mid \mathbf{x}')$, we label \mathbf{x}' to be “No”.