

Naive Bayes Intuition { Classification }

⇓

{ BAYE'S THEOREM }

Rolling a Dice  
 $\{1, 2, 3, 4, 5, 6\}$

$P(1) = \frac{1}{6}$        $P(3) = \frac{1}{6}$   
 $P(2) = \frac{1}{6}$

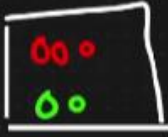
{ Independent Events }

1,2,3,4,5,6 are **independent**, not dependent on each other

Dependent Event

First Event  
 $P(R) = \frac{3}{5} \rightarrow R$

Green Marble  
 $P(G) = \frac{2}{4} = \frac{1}{2}$



i) We find the probability of  $p(R)$  marbles;

ii) Later, we find  $p(G): \frac{2}{4} = \frac{1}{2}$ ,

$\frac{2}{4}$  because the red marble we found, is removed!

It's called dependent, because no. of marbles are getting reduced, as we take it out!

iii) prob. of taking out a red marble then a green marble:

$$P(R \text{ and } G) = P(R) * P(G/R)$$

→ Conditional Probability  
 →

Hence, →

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

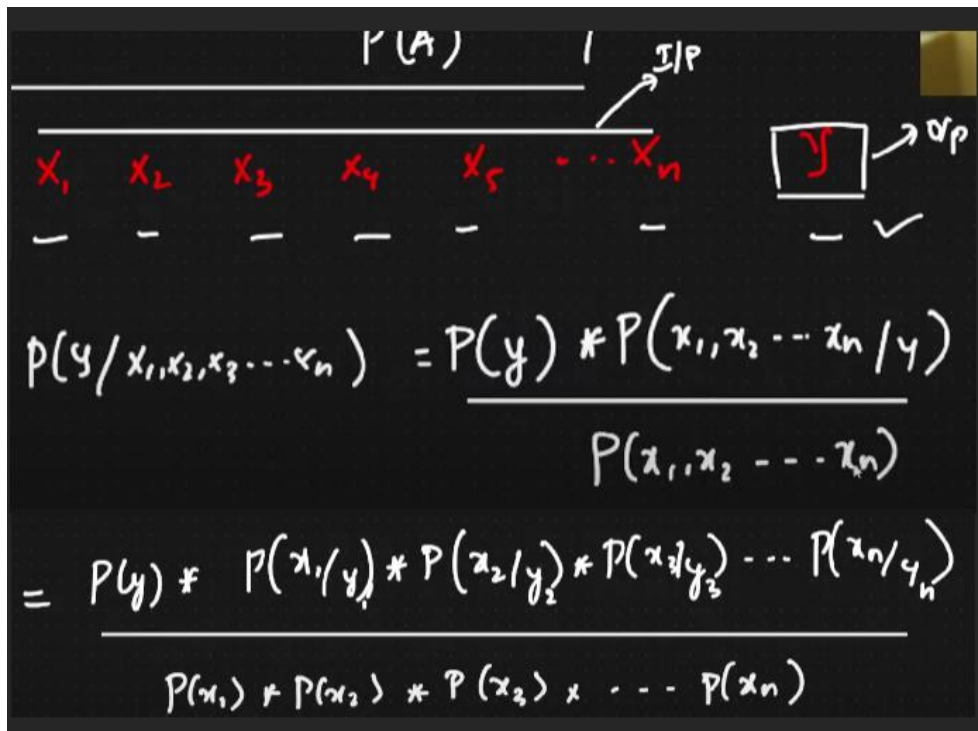
$$\Rightarrow P(A \text{ and } B) = P(B \text{ and } A) \quad \{ \text{Yes} \}$$

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

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

→ Bayes Theorem (RUX Naive Bayes)

X(input) and y(output):



$$P(A)$$

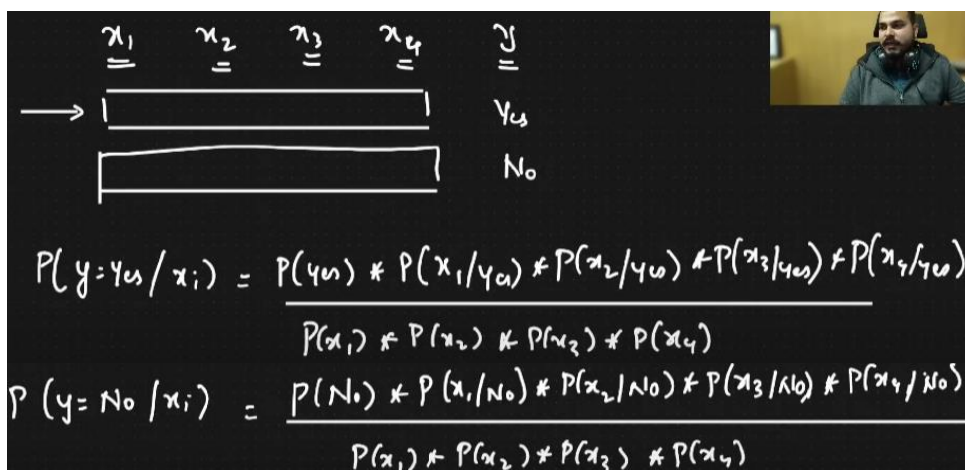
I/P

O/P

$$P(y/x_1, x_2, x_3, \dots, x_n) = \frac{P(y) * P(x_1, x_2, \dots, x_n | y)}{P(x_1, x_2, \dots, x_n)}$$

$$= \frac{P(y) * P(x_1/y) * P(x_2/y) * P(x_3/y) * \dots * P(x_n/y)}{P(x_1) * P(x_2) * P(x_3) * \dots * P(x_n)}$$

The dependent value is Yes or No?



$x_1, x_2, x_3, x_4$

$y$

Yes

No

$$P(y=Yes/x_1) = \frac{P(Yes) * P(x_1/Yes) * P(x_2/Yes) * P(x_3/Yes) * P(x_4/Yes)}{P(x_1) * P(x_2) * P(x_3) * P(x_4)}$$

$$P(y=No/x_1) = \frac{P(No) * P(x_1/No) * P(x_2/No) * P(x_3/No) * P(x_4/No)}{P(x_1) * P(x_2) * P(x_3) * P(x_4)}$$

Xi will be either yes or no, need to check!

But the denominator will be same in all the case,

Hence, constant & so can be removed;

And use just nominator!



$x_i$

Yes

No

$$P(\text{Yes} | x_i) = \boxed{0.13} \quad P(\text{No} | x_i) = \boxed{0.05}$$

$$\geq 0.5 \Rightarrow 1$$

$$< 0.5 \Rightarrow 0$$

What should be the output of the given  $x_i$ ?  
Yes or No?

→ perform normalization:

$$P(\text{Yes} | x_i) = \frac{0.13}{0.13 + 0.05} = 0.72 = 72\%$$

$$P(\text{No} | x_i) = 1 - 0.72 = 0.28 = 28\%$$

Answer → Yes, as it has a favour of 72%.

Real-Life data:

DATA SET

Binary class

Day	Outlook	Temperature	Humidity	Wind	Play Tennis
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

**Dependent features (X):**

Outlook, Temperature,  
Humidity, Wind!

**Independent feature (y):** Play  
Tennis, a binary classification!

Dependent features:

$x_1$

Outlook

	Yes	No	$P(Y)$	$P(N)$
Sunny	2	3	2/9	3/5
Overcast	4	0	4/9	0/5
Rain	3	2	3/9	2/5
<b>Total</b>	<b>9</b>	<b>5</b>		

Temperature

	Yes	No	$P(Y)$	$P(N)$
Hot	2	2	2/9	2/5
Mild	4	2	4/9	2/5
Cold	3	1	3/9	1/5
<b>Total</b>	<b>9</b>	<b>5</b>		

Independent feature:

PLAY

	Yes	No	$P(\text{Yes})$	$P(\text{No})$
Yes	9		$\frac{9}{14}$	$\frac{5}{14}$
No		5		
<b>Total</b>	<b>14</b>			

What if we get a test data, like: (refer: conditional probability pt.)

$$\rightarrow \text{Test } (\text{Sunny}, \text{Hot}) \rightarrow \text{o/p}$$

$$P(\text{Yes} | \text{Sunny}, \text{Hot}) = \frac{P(\text{Yes}) * P(\text{Sunny} | \text{Yes}) * P(\text{Hot} | \text{Yes})}{P(\text{Sunny}) * P(\text{Hot})}$$

The denominator will be ignored, as it's constant!

$$= \frac{1}{14} * \frac{2}{7} * \frac{2}{5}$$

$$= \frac{2}{63} = 0.031$$

$$P(\text{Yes} | \text{Sunny}, \text{Hot}) = \frac{P(\text{Yes}) * P(\text{Sunny} | \text{Yes}) * P(\text{Hot} | \text{Yes})}{P(\text{Sunny}) * P(\text{Hot})}$$

Similarly,

$$P(\text{No} | \text{Sunny}, \text{Hot}) = \frac{P(\text{No}) * P(\text{Sunny} | \text{No}) * P(\text{Hot} | \text{No})}{P(\text{Sunny}) * P(\text{Hot}) \rightarrow \text{constant}}$$

$$= \frac{8}{14} * \frac{3}{5} * \frac{2}{5}$$

$$= \frac{3}{35} = 0.085$$

Normalization:

$$P(\text{Yes} | \text{Sunny}, \text{Hot}) = 0.031 \quad = 1 - 0.73 = 0.27 = 27\%$$

$$P(\text{No} | \text{Sunny}, \text{Hot}) = 0.085 = \frac{0.085}{0.031 + 0.085} = 0.73 = 73\%$$

$\rightarrow (\text{Sunny}, \text{hot}) \rightarrow \text{Yes or No}$

Answer  $\rightarrow \text{No} \checkmark$

Assignment:

Find the probability for: (Overcast, Mild)!

Reference:

[1\) Naive Baye's Concept Explanation](#)