Naive Bayes

$$P(A|B) = \frac{P(B|A)\,P(A)}{P(B)}$$ (Bayes theory)

Temp	Play Tennis
70 [W]	Yes
32	No
65 [W]	No
75 [W]	Yes
30	No
75 [W]	Yes
72 [W]	No

⇒ if temp > 50 then the temp is Warm.

↳ Numeric value to categorical value.

⇒ Given the temp is warm calculate the probability of playing tennis.

$$\Rightarrow P(P|W) = \frac{P(W|P)\,P(P)}{P(W)}$$

$$= \frac{3/3 \cdot 3/7}{5/7}$$

$$= 0.6$$

$$\Rightarrow P(\neg P|W) = 1 - 0.6$$

$$= 0.4.$$

$\Rightarrow P(P) = \frac{3}{7}$

↳ Probability of playing tennis.

$\Rightarrow P(W) = \frac{5}{7}$

↳ Probability of warm

$\Rightarrow P(W|P) = \frac{3}{3}$

$\frac{W(3)}{Yes(3)}$

⇒ Calculate whether player will play tennis or not given the weather is warm.

$$P(P|W) = \frac{P(W|P)\,P(P)}{P(W)}$$

$$P(\neg P|W) = \frac{P(W|\neg P)\,P(\neg P)}{P(W)}$$

⇒ So, we omit the denominator here.

$$P(P|W) = P(W|P)\,P(P)$$
$$= 3/3 \times 3/7 = \frac{9}{21} = \frac{3}{7}$$

$$P(\neg P|W) = P(W|\neg P)\,P(\neg P)$$
$$= 2/4 \times 4/7$$
$$= \frac{8}{28} = \frac{2}{7}$$

⇒ As $\frac{3}{7} > \frac{2}{7}$, there is a chance that the player will play tennis.

Ans

□ Table in page number 9 (Naive Bayes PDF).

⇒ Based on that table calculate if the player will play tennis given outlook is Sunny; temp is cool; humidity is high; wind speed is strong.

□ $P(P \mid S \cap H \cap C \cap ST)$?

$P(\neg P \mid S \cap H \cap C \cap ST)$

$\cancel{P(P \mid S \cap H \cap C \cap ST) =} \quad \cancel{P[(S \cap H \cap C \cap ST) \mid P]}$

⇒ So according to $P(A \mid B) = \dfrac{P(B \mid A)\, P(A)}{P(B)}$;

$$P(P \mid S \cap C \cap H \cap ST) = \frac{P(S \cap C \cap H \cap ST \mid P)\, P(P)}{P(S \cap C \cap H \cap ST)}$$

↳ Similar goes for not playing.

⇒ For $P(S \cap C \cap H \cap ST \mid P)$ we need to find the "playing ∩ "YES" tennis" rows first and then "$S \cap C \cap H \cap ST$" combination. But you won't find $S \cap C \cap H \cap ST$ occurring at the same time for playing tennis. So, $P(S \cap C \cap H \cap ST)$ will be 0. And for this the probability will be 0.

⇒ This is known as "Zero probability problem" of Bayes Theorem.

So, how do we solve this problem?

Conditional Probability: This is not exactly given but we forcefully making it, that's why it is Naive Bayes

$$\Rightarrow P(A \cap B | C) = P(A|C) \cdot P(B|C)$$

$$\Rightarrow P(A \cap B \cap C \cap D | E) = P(A|E)\, P(B|E)\, P(C|E)\, P(D|E)$$

Now using this law:

$$P(P | S \cap C \cap H \cap ST) = \frac{P(S \cap C \cap H \cap ST | P) \times P(P)}{P(S \cap C \cap H \cap ST)}$$

$$P(\neg P | S \cap C \cap H \cap ST) = \frac{P(S \cap C \cap H \cap ST | \neg P)\, P(\neg P)}{P(S \cap C \cap H \cap ST)}$$

→ We omit the denominator.

$$\Rightarrow P(S \cap C \cap H \cap ST | P) \times P(P)$$

$$\Rightarrow P(S|P) \times P(C|P) \times P(H|P) \times P(ST|P) \times P(P)$$

$$\Rightarrow \frac{2}{9} \times \frac{3}{9} \times \frac{3}{9} \times \frac{3}{9} \times \frac{9}{14}$$

$$\Rightarrow 0.0053$$

You can use the learning phase table from Slide/PDF page 9.

$$\Rightarrow P(S \cap C \cap H \cap ST | \neg P) \times P(\neg P)$$

$$\Rightarrow P(S|\neg P) \times P(C|\neg P) \times P(H|\neg P) \times P(ST|\neg P) \times P(\neg P)$$

$$\Rightarrow 3/5 \times 1/5 \times 4/5 \times 3/5 \times \frac{5}{14} = 0.0206$$

So the player not likely to play tennis.