

# 機器學習

## Naive Bayes

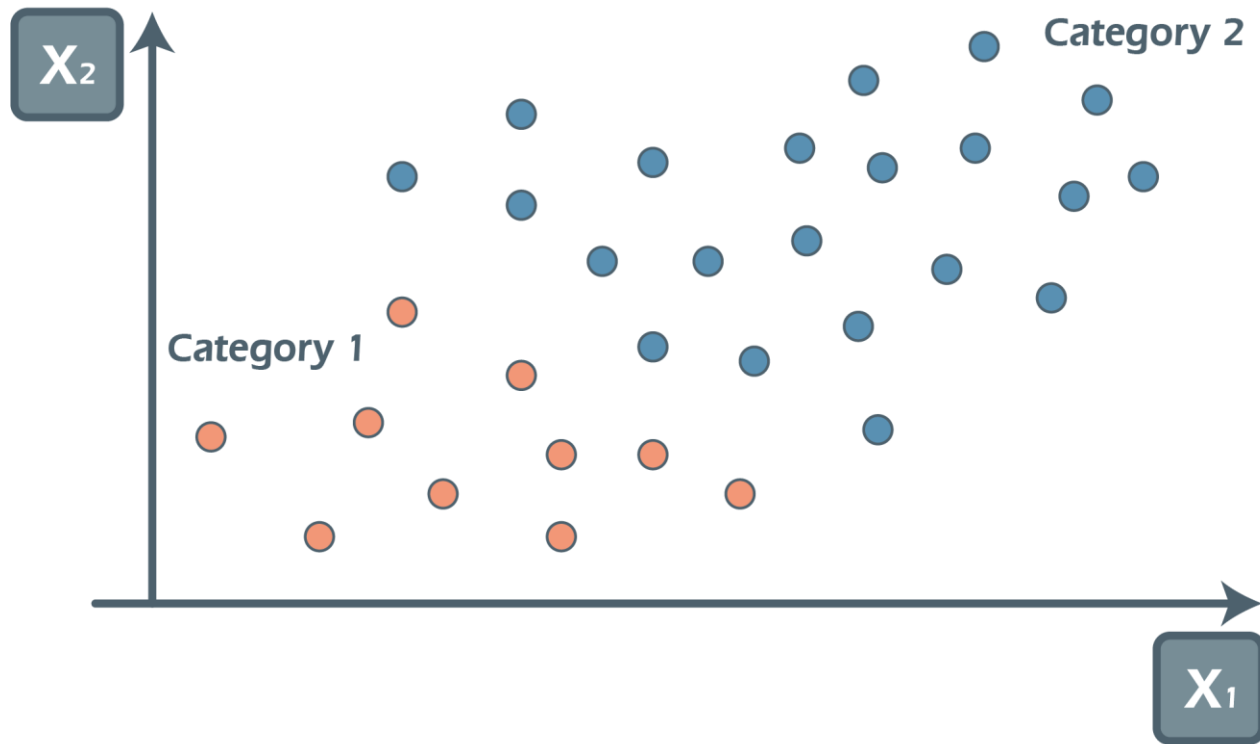
授課老師：林彥廷

# Naive Bayes Classifier Intuition

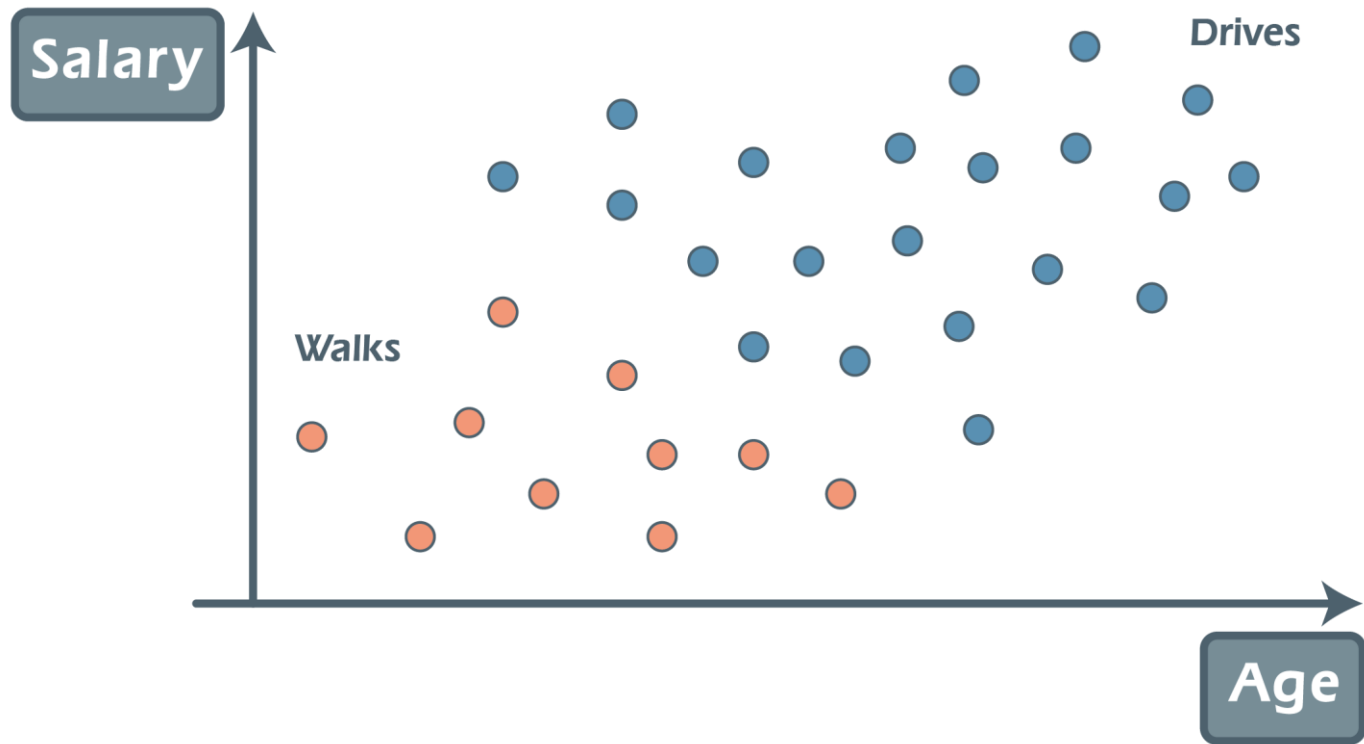
# Naive Bayes

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

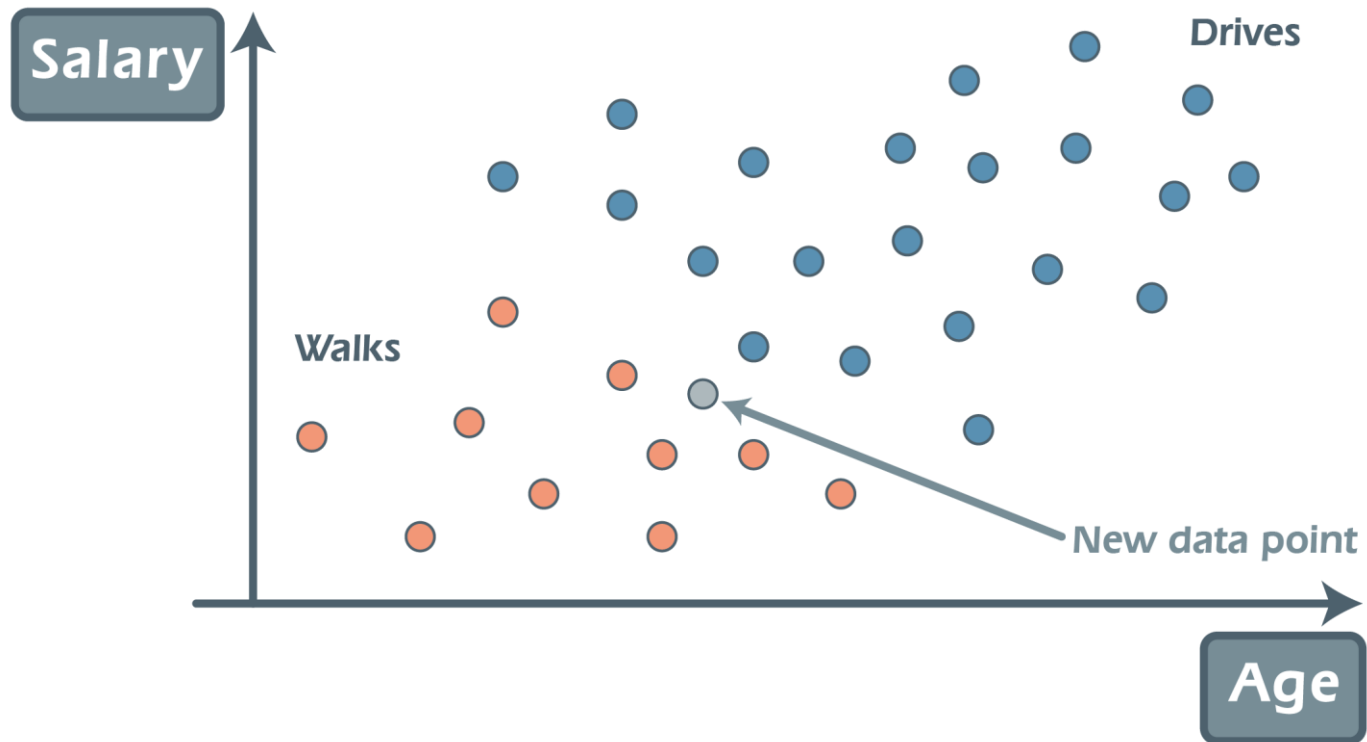
# Naive Bayes



# Naive Bayes



# Naive Bayes



Naive Bayes

**Plan of Attack**

# Naive Bayes

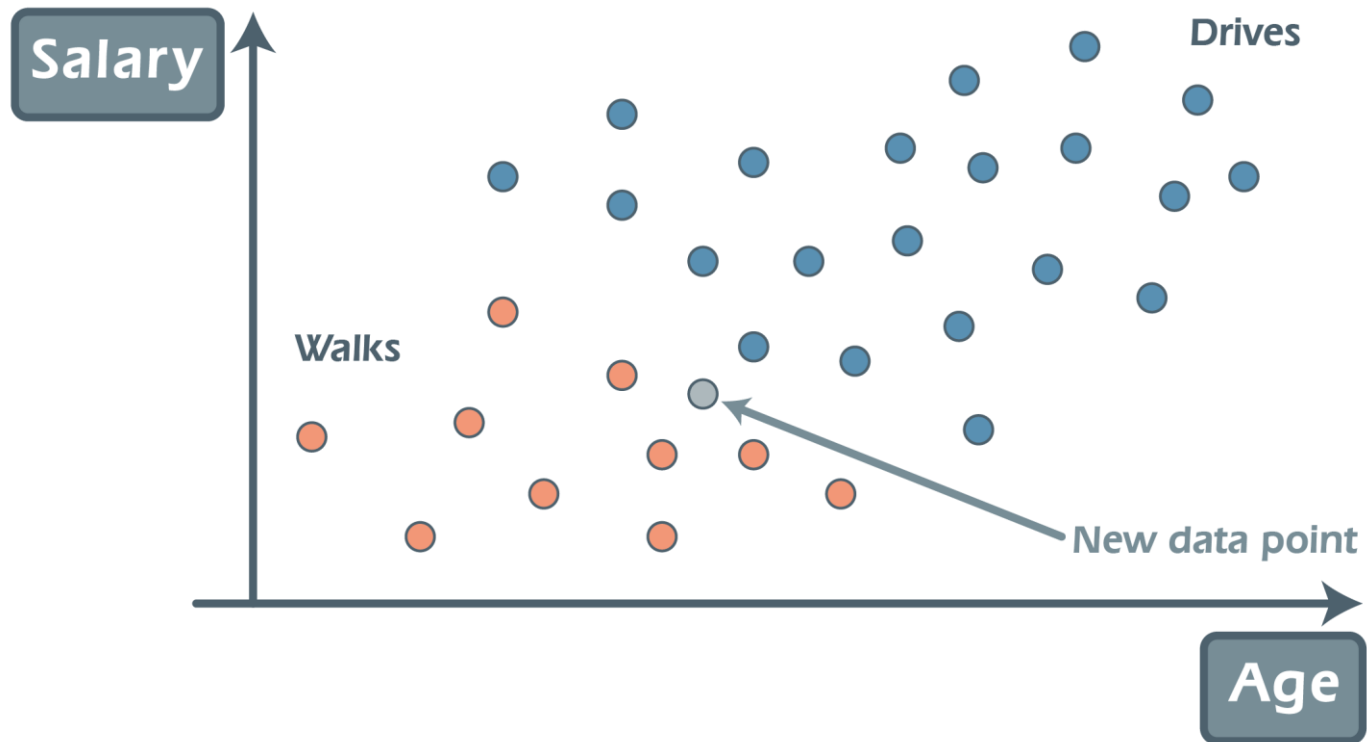
$$P(A|B) = \frac{P(B|A) * P(A)}{P(B)}$$



# Naive Bayes

$$P(Walks|X) = \frac{P(X|Walks) * P(Walks)}{P(X)}$$

# Naive Bayes

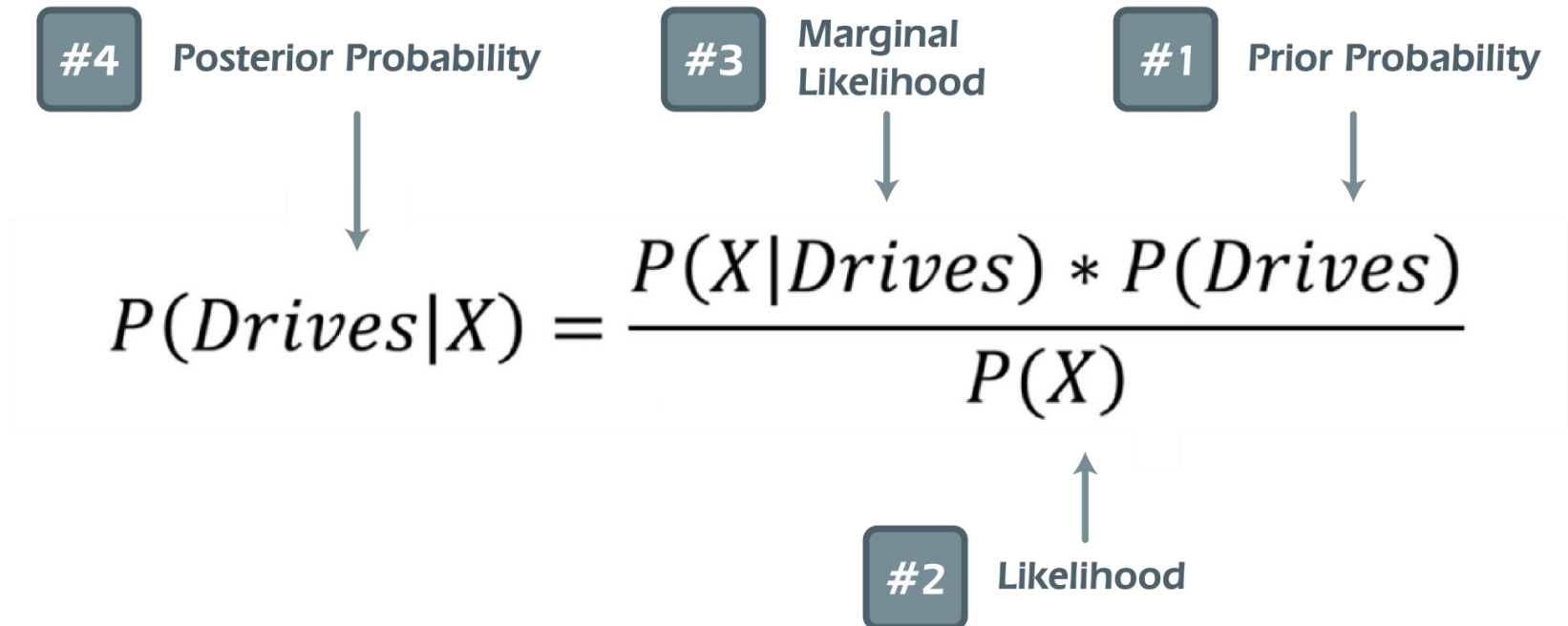


# Naive Bayes

The diagram illustrates the Naive Bayes formula with four numbered components in grey boxes: #1 (Prior Probability), #2 (Likelihood), #3 (Marginal Likelihood), and #4 (Posterior Probability). Arrows indicate their placement in the formula: #1 points to  $P(Walks)$ , #2 points to  $P(X)$ , #3 points to the numerator, and #4 points to the left side of the equation.

$$\begin{array}{c} \text{\#4 Posterior Probability} \\ \downarrow \\ P(Walks|X) = \end{array} \frac{\begin{array}{c} \text{\#3 Marginal Likelihood} \\ \downarrow \end{array} P(X|Walks) * \begin{array}{c} \text{\#1 Prior Probability} \\ \downarrow \end{array} P(Walks)}{\begin{array}{c} \text{\#2 Likelihood} \\ \uparrow \\ P(X) \end{array}}$$

# Naive Bayes



#4 Posterior Probability

#3 Marginal Likelihood

#1 Prior Probability

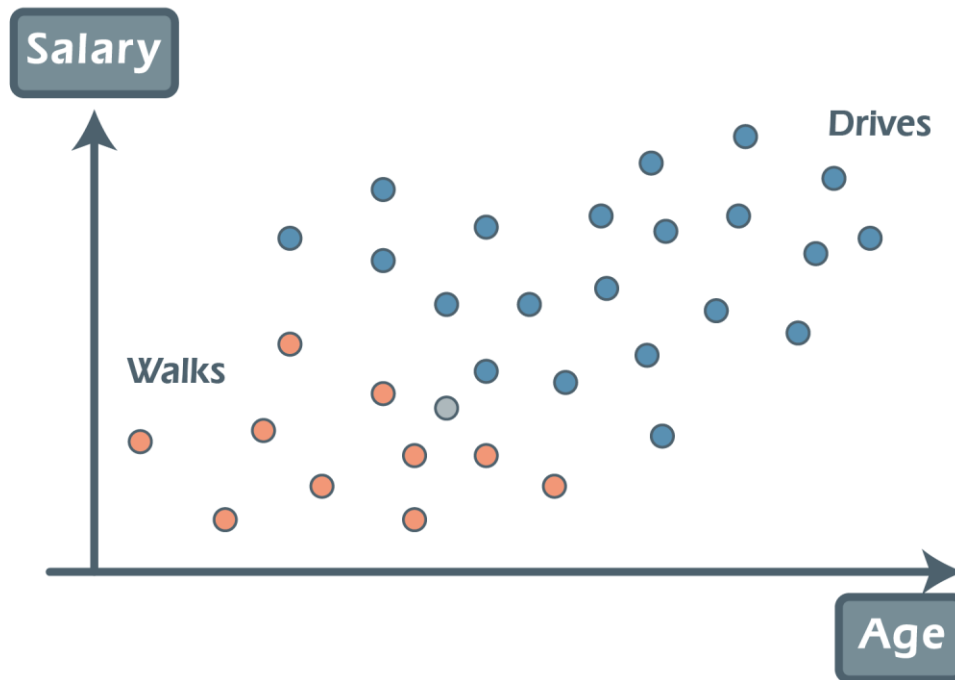
#2 Likelihood

$$P(Drives|X) = \frac{P(X|Drives) * P(Drives)}{P(X)}$$

# Naive Bayes

*$P(Walks|X)$  v. s.  $P(Drives|X)$*

# Naive Bayes

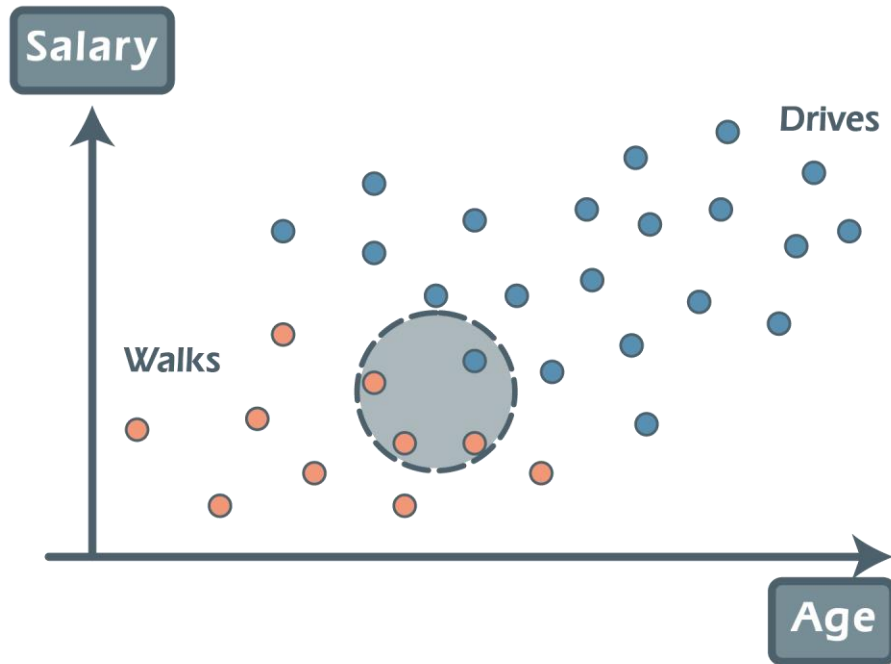


# Naive Bayes

The diagram illustrates the Naive Bayes formula with four numbered components in grey boxes: #4 (Posterior Probability) points to the left side of the equation; #3 (Marginal Likelihood) points to the denominator; #1 (Prior Probability) points to the  $P(Walks)$  term in the numerator; and #2 (Likelihood) points to the  $P(X|Walks)$  term in the numerator.

$$\begin{array}{c} \text{\#4 Posterior Probability} \\ \downarrow \\ P(Walks|X) \end{array} = \frac{\begin{array}{c} \text{\#3 Marginal Likelihood} \\ \downarrow \\ P(X|Walks) \end{array} * \begin{array}{c} \text{\#1 Prior Probability} \\ \downarrow \\ P(Walks) \end{array}}{\begin{array}{c} \text{\#2 Likelihood} \\ \uparrow \\ P(X) \end{array}}$$

# Naive Bayes



#2.  $P(X)$

$$P(X) = \frac{\text{Number of Similar Observations}}{\text{Total Observations}}$$

$$P(X) = \frac{4}{30}$$



# Naive Bayes

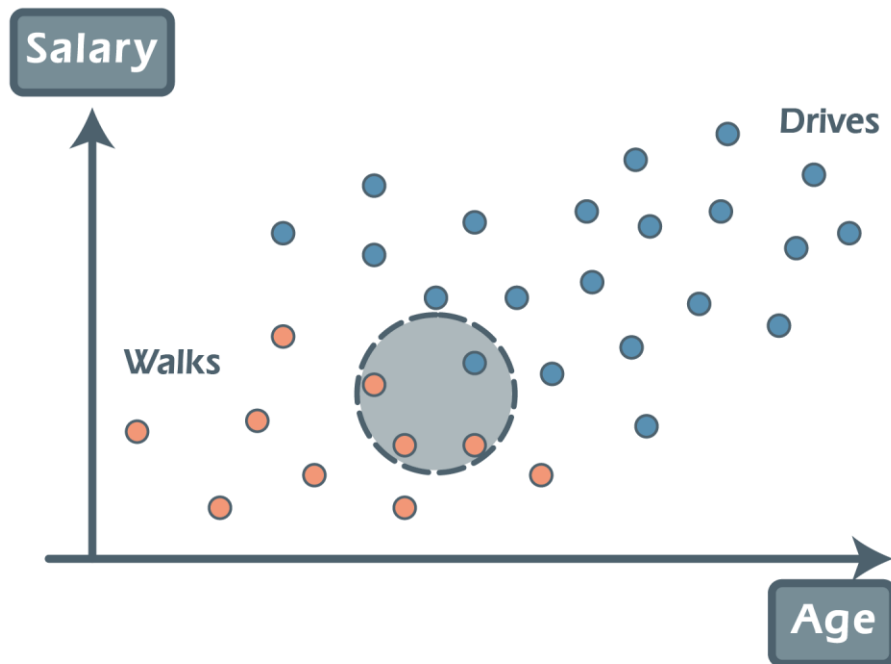
The diagram illustrates the Naive Bayes formula with four numbered components in grey boxes: #1 (Prior Probability) points to  $P(Walks)$ , #2 (Likelihood) points to  $P(X)$ , #3 (Marginal Likelihood) points to the denominator  $P(X)$ , and #4 (Posterior Probability) points to the entire formula. The formula is displayed as follows:

$$P(Walks|X) = \frac{P(X|Walks) * P(Walks)}{P(X)}$$

Labels and arrows:

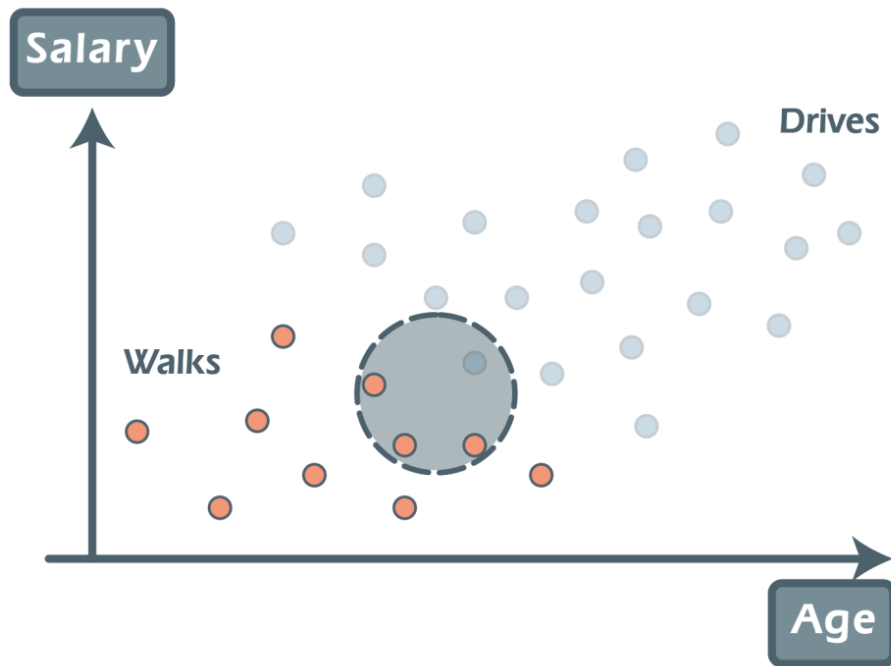
- #4 Posterior Probability (points to the entire equation)
- #3 Marginal Likelihood (points to the denominator  $P(X)$ )
- #1 Prior Probability (points to  $P(Walks)$ )
- #2 Likelihood (points to  $P(X)$ )

# Naive Bayes

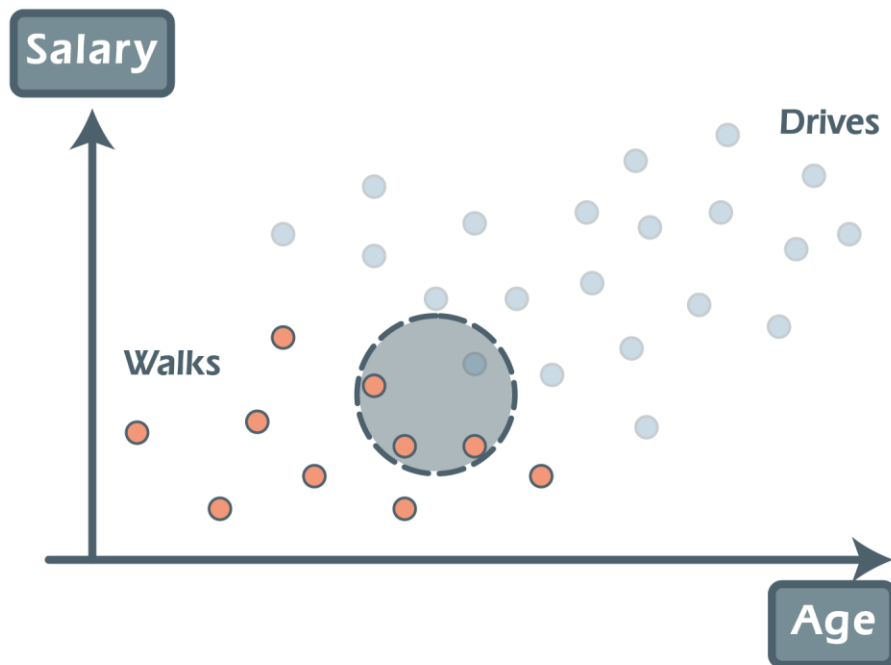


#3.  $P(X | \text{Walks})$

# Naive Bayes



# Naive Bayes



## #3. $P(X|Walks)$

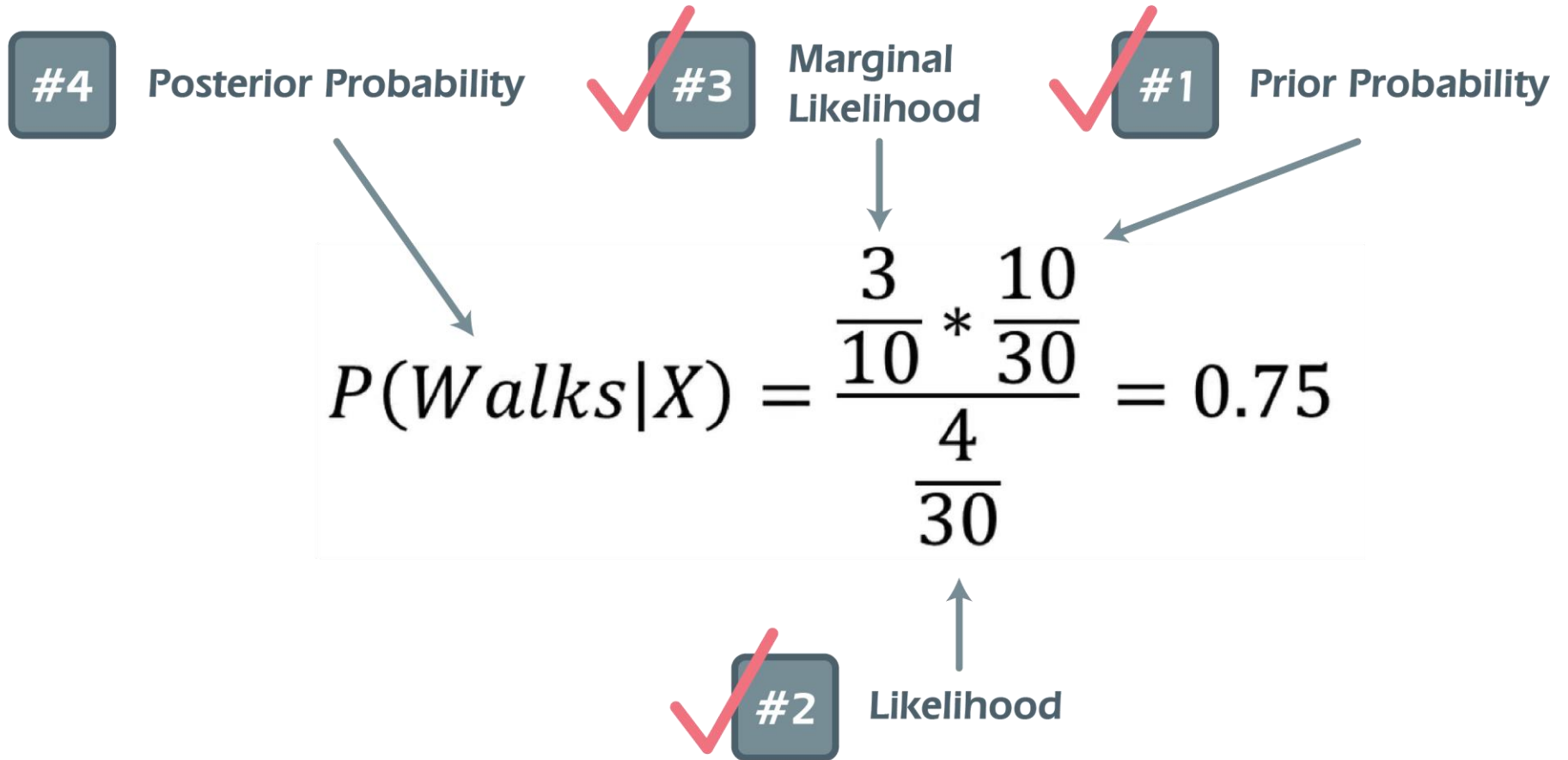
$$P(X|Walks) = \frac{\text{Number of Similar Observations Among those who Walk}}{\text{Total number of Walkers}}$$
$$P(X|Walks) = \frac{3}{10}$$

# Naive Bayes

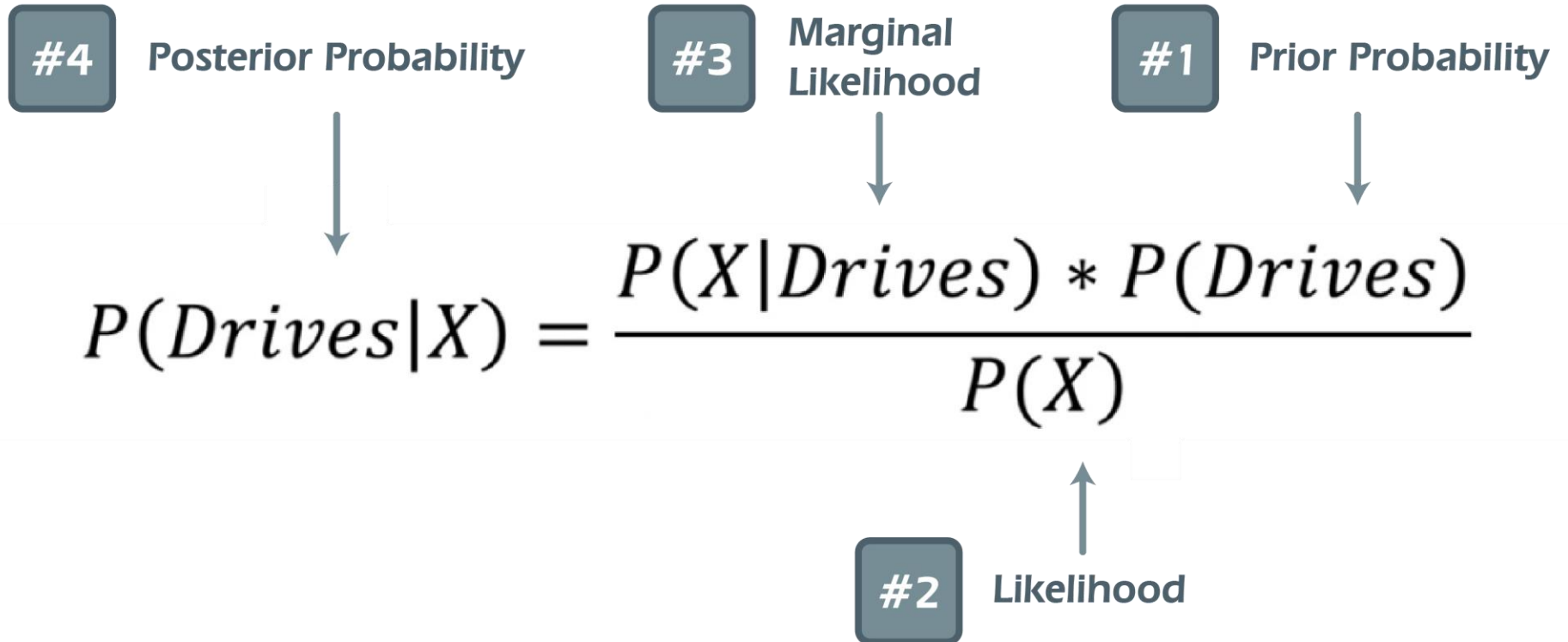
The diagram illustrates the Naive Bayes formula with four numbered components in grey boxes: #1 Prior Probability, #2 Likelihood, #3 Marginal Likelihood, and #4 Posterior Probability. Arrows indicate their placement in the formula: #1 points to  $P(Walks)$ , #2 points to  $P(X)$ , #3 points to the numerator, and #4 points to the left side of the equation.

$$\begin{array}{c} \text{\#4 Posterior Probability} \\ \downarrow \\ P(Walks|X) \end{array} = \frac{\begin{array}{c} \text{\#3 Marginal Likelihood} \\ \downarrow \\ P(X|Walks) * P(Walks) \end{array}}{\begin{array}{c} \text{\#2 Likelihood} \\ \uparrow \\ P(X) \end{array}} \begin{array}{c} \text{\#1 Prior Probability} \\ \downarrow \end{array}$$

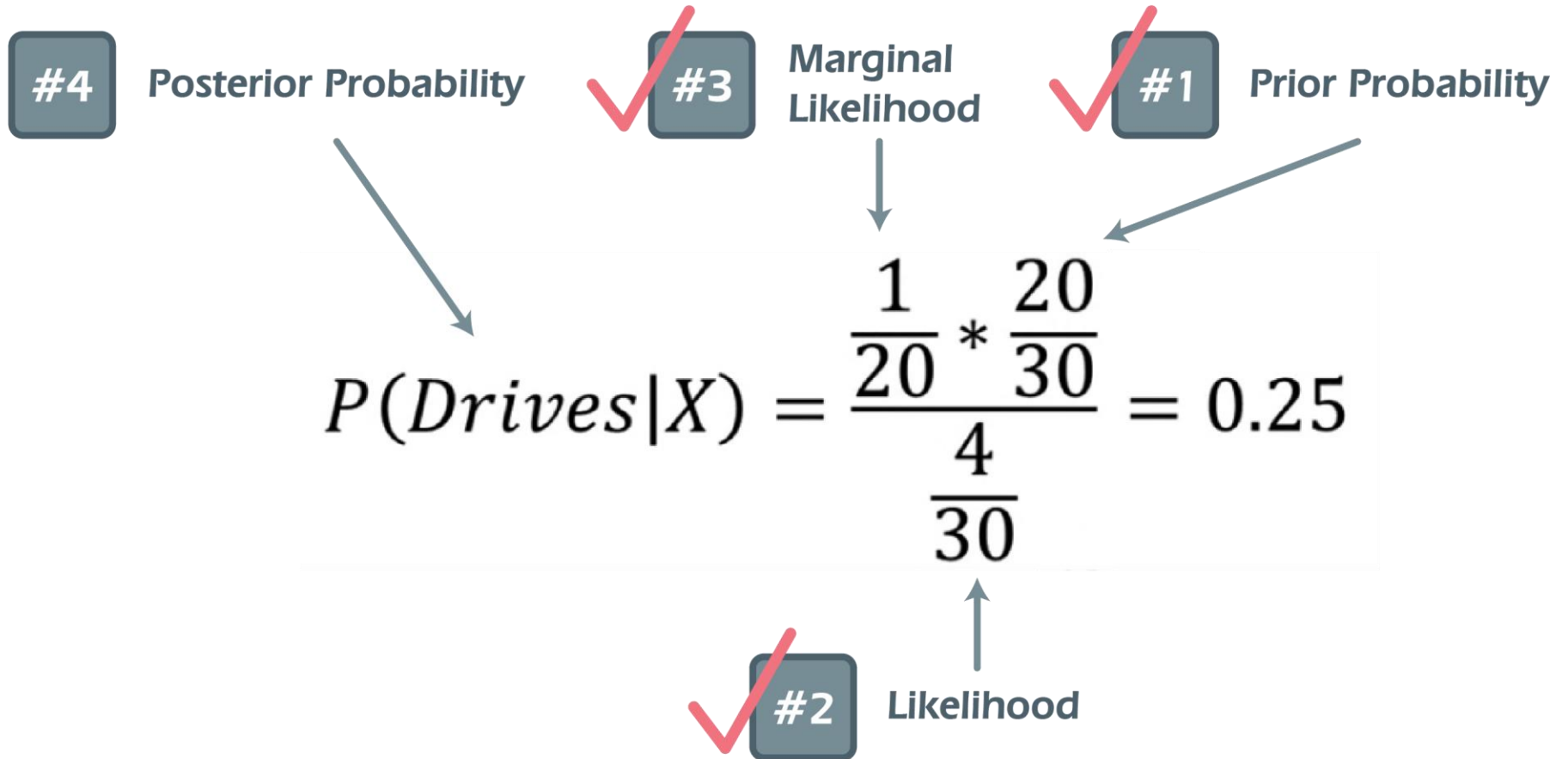
# Naive Bayes



# Naive Bayes



# Naive Bayes





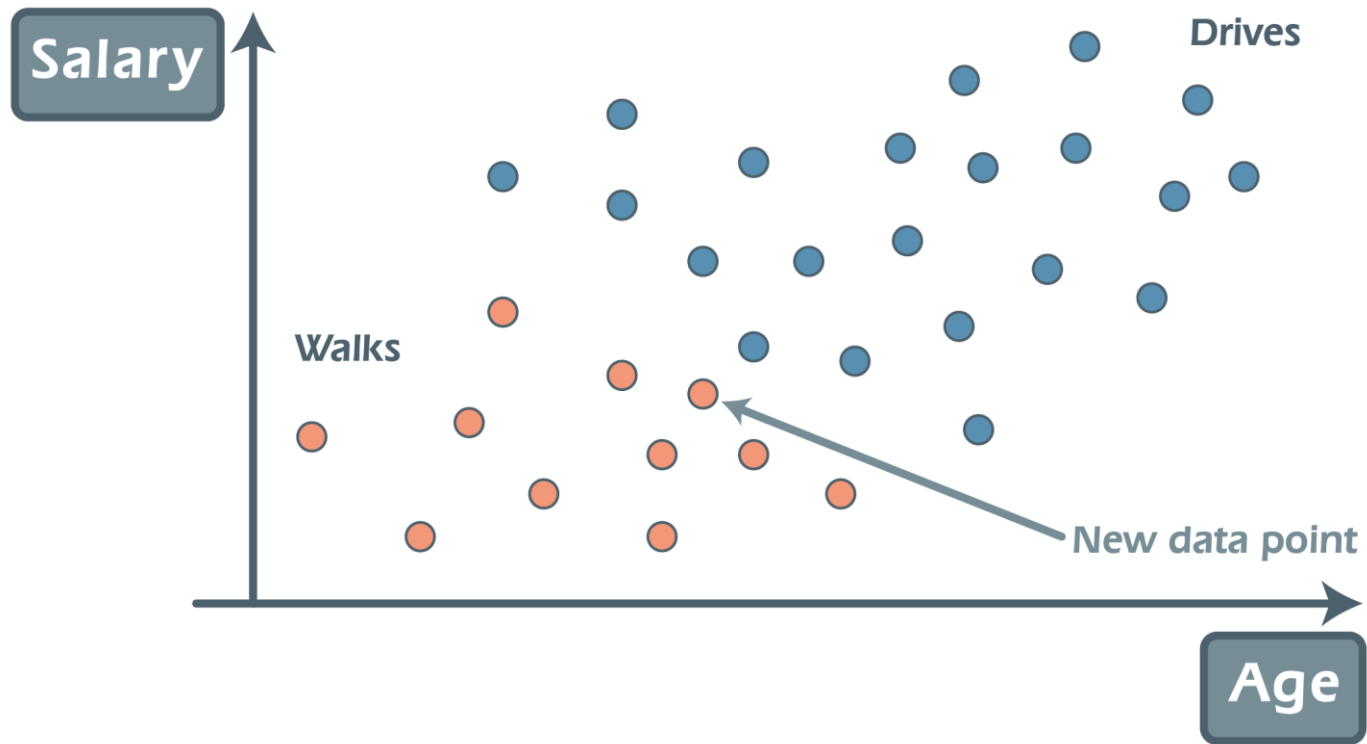
# Naive Bayes

*$P(Walks|X)$  v.s.  $P(Drives|X)$*

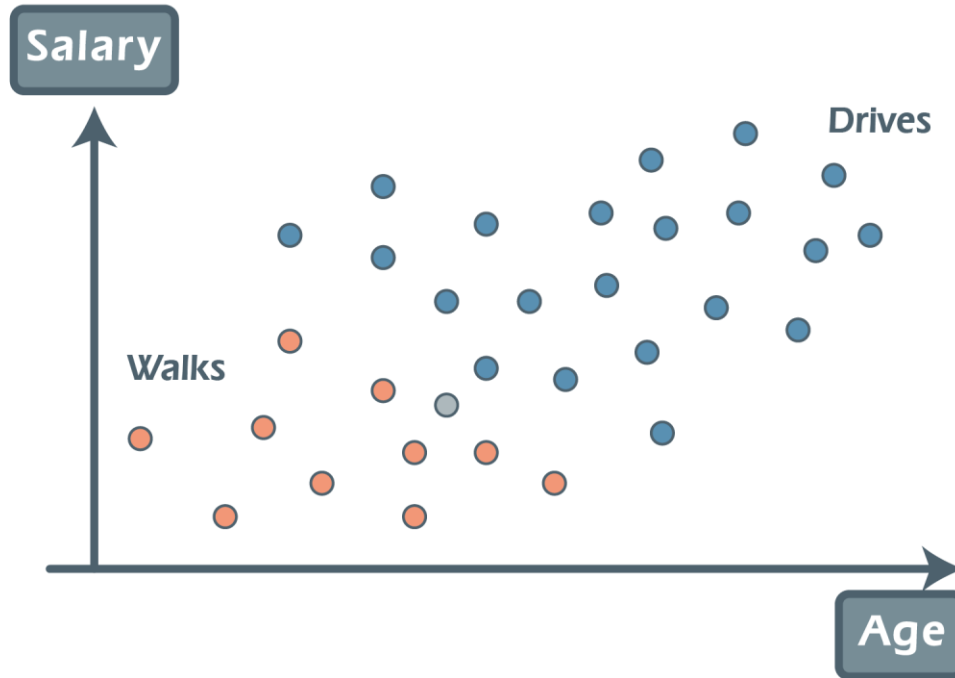
# Naive Bayes

$$0.75 > 0.25$$

# Naive Bayes



# Naive Bayes

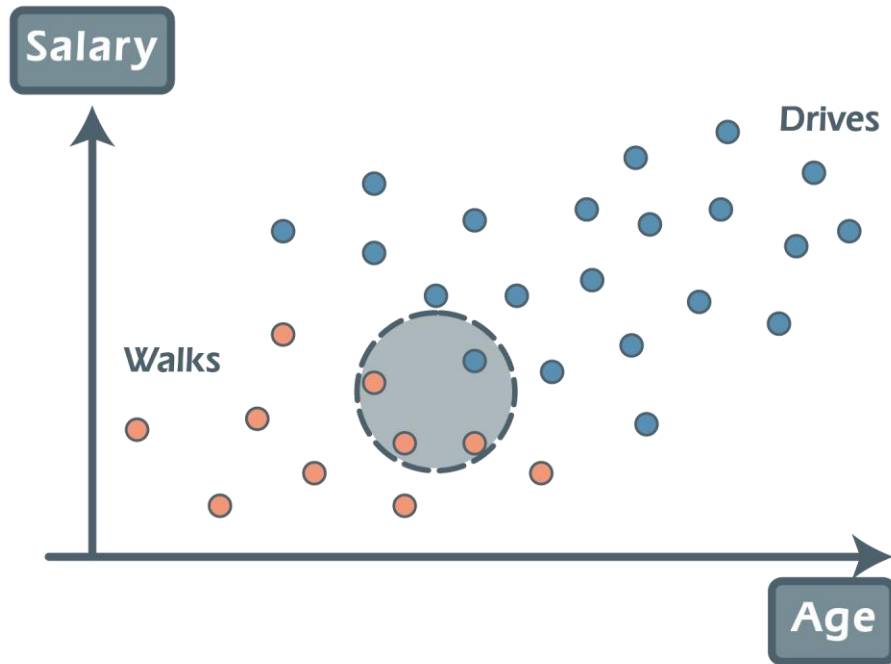


## #1. $P(\text{Drives})$

$$P(\text{Drives}) = \frac{\text{Number of Drivers}}{\text{Total Observations}}$$

$$P(\text{Drives}) = \frac{20}{30}$$

# Naive Bayes

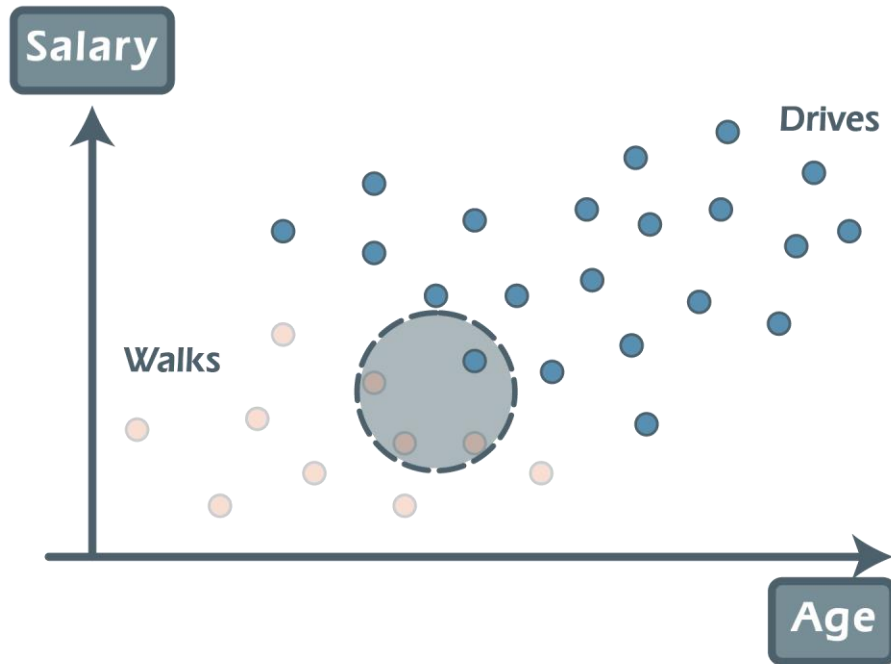


#2.  $P(X)$

$$P(X) = \frac{\text{Number of Similar Observations}}{\text{Total Observations}}$$

$$P(X) = \frac{4}{30}$$

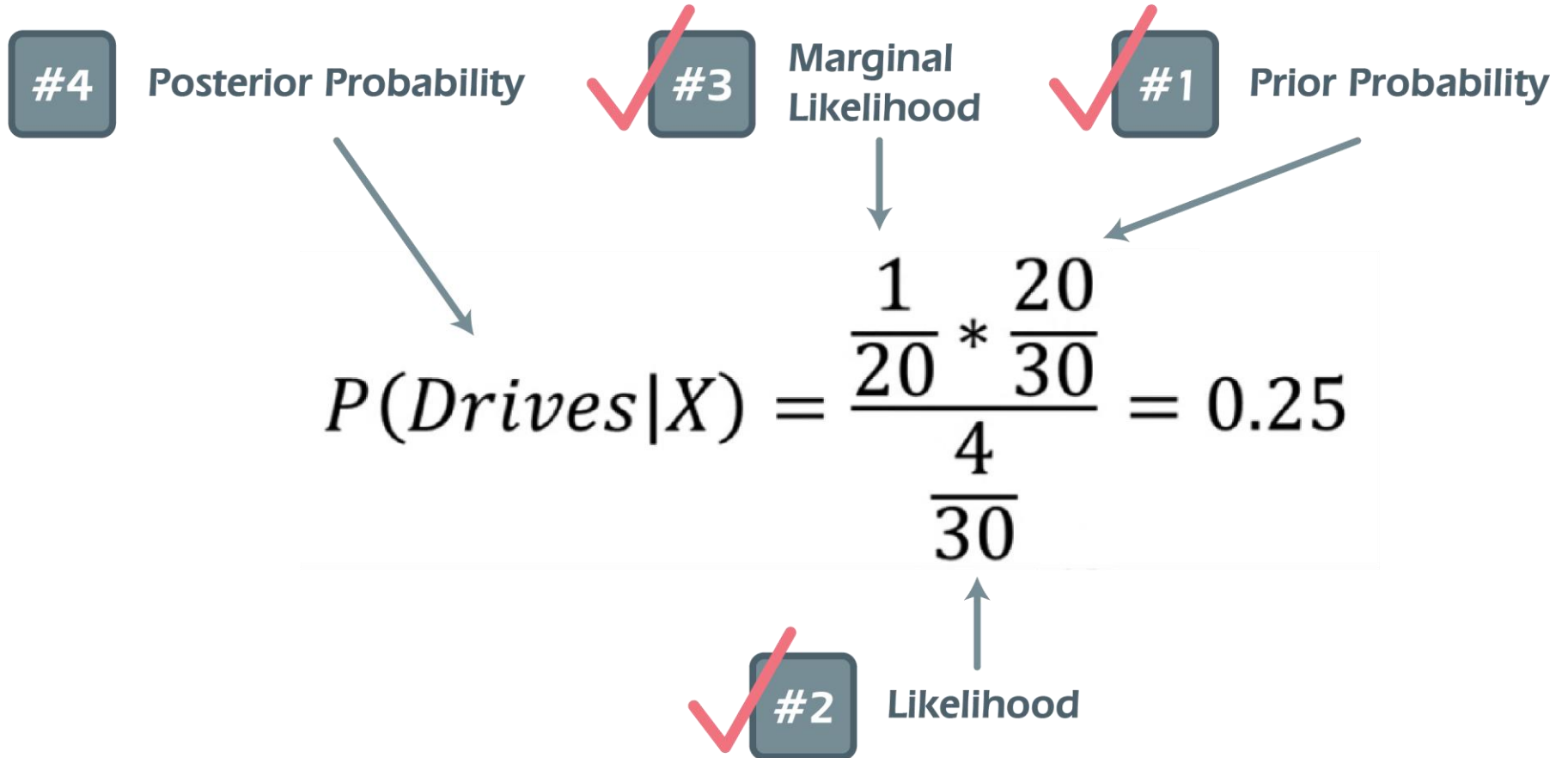
# Naive Bayes



## #3. $P(X| \text{Drives})$

$$P(X|\text{Drives}) = \frac{\text{Number of Similar Observations Among those who Walk}}{\text{Total number of Walkers}}$$
$$P(X|\text{Drives}) = \frac{1}{20}$$

# Naive Bayes



# Naive Bayes

- 1. Q: Why "Naive"?**
- 2.  $P(X)$**
- 3. More than 2 classes**



# Naive Bayes

**Q: Why "Naive"?**

**A: Independence assumption**

# Naive Bayes

$$\mathbf{P(X)}$$

# Naive Bayes

$$\frac{P(X|Walks) * P(Walks)}{P(X)} \quad v.s. \quad \frac{P(X|Drives) * P(Drives)}{P(X)}$$

# Naive Bayes

$$\frac{P(X|Walks) * P(Walks)}{\cancel{P(X)}} \text{ v.s. } \frac{P(X|Drives) * P(Drives)}{\cancel{P(X)}}$$

Naive Bayes

**More than 2 classes**

# Naive Bayes

$P(Walks|X)$  v.s.  $P(Drives|X)$

THE END

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