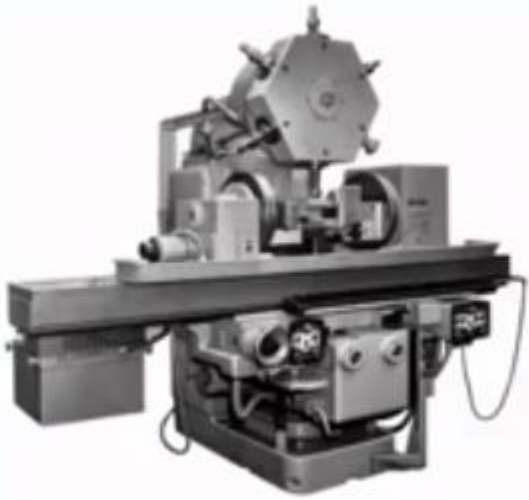
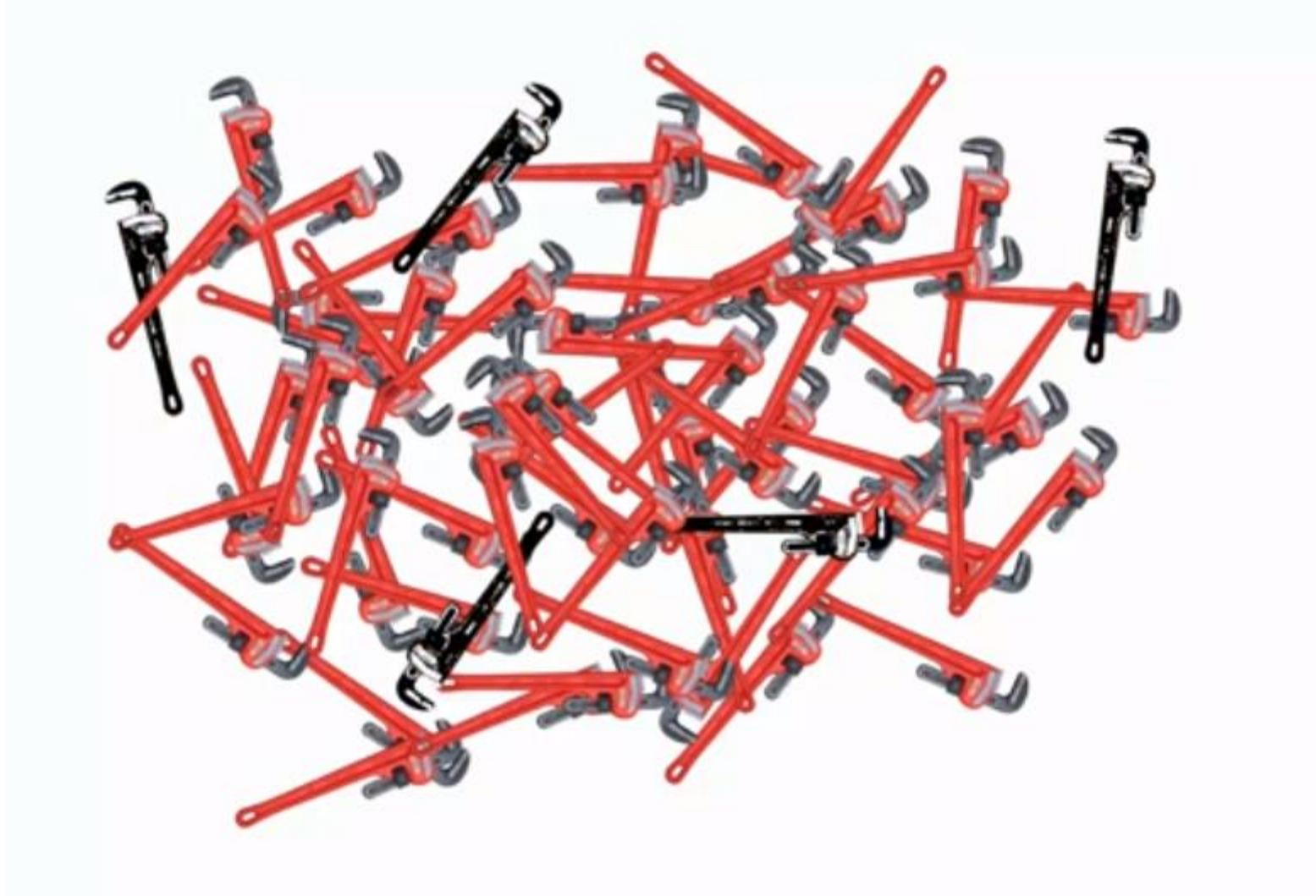




# Naive Bayes Classification





# What's the probability?



m2



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

**Mach1: 30 wrenches / hr**  
**Mach2: 20 wrenches / hr**

**Mach1: 30 wrenches / hr**  
**Mach2: 20 wrenches / hr**

**Out of all produced parts:**  
**We can SEE that 1% are defective**



**Mach1: 30 wrenches / hr**

**Mach2: 20 wrenches / hr**

**Out of all produced parts:**

**We can SEE that 1% are defective**

**Out of all defective parts:**

**We can SEE that 50% came from mach1**

**And 50% came from mach2**



**Mach1: 30 wrenches / hr**  
**Mach2: 20 wrenches / hr**

**Out of all produced parts:**  
**We can SEE that 1% are defective**

**Out of all defective parts:**  
**We can SEE that 50% came from mach1**  
**And 50% came from mach2**

**Question:**  
**What is the probability that a part**  
**produced by mach2 is defective = ?**

**Mach1: 30 wrenches / hr**  
**Mach2: 20 wrenches / hr**

$$\rightarrow P(\text{Mach1}) = 30/50 = 0.6$$

**Out of all produced parts:**  
**We can SEE that 1% are defective**

**Out of all defective parts:**  
**We can SEE that 50% came from mach1**  
**And 50% came from mach2**

**Question:**  
**What is the probability that a part**  
**produced by mach2 is defective = ?**

**Mach1: 30 wrenches / hr**  
**Mach2: 20 wrenches / hr**

$$\rightarrow P(\text{Mach1}) = 30/50 = 0.6$$
$$\rightarrow P(\text{Mach2}) = 20/50 = 0.4$$

**Out of all produced parts:**  
**We can SEE that 1% are defective**

**Out of all defective parts:**  
**We can SEE that 50% came from mach1**  
**And 50% came from mach2**

**Question:**  
**What is the probability that a part**  
**produced by mach2 is defective = ?**

**Mach1: 30 wrenches / hr**

**Mach2: 20 wrenches / hr**

$$\rightarrow P(\text{Mach1}) = 30/50 = 0.6$$

$$\rightarrow P(\text{Mach2}) = 20/50 = 0.4$$

**Out of all produced parts:**

**We can SEE that 1% are defective**

$$\rightarrow P(\text{Defect}) = 1\%$$

**Out of all defective parts:**

**We can SEE that 50% came from mach1**

**And 50% came from mach2**

**Question:**

**What is the probability that a part  
produced by mach2 is defective = ?**



**Mach1: 30 wrenches / hr**

**Mach2: 20 wrenches / hr**

$$\rightarrow P(\text{Mach1}) = 30/50 = 0.6$$

$$\rightarrow P(\text{Mach2}) = 20/50 = 0.4$$

**Out of all produced parts:**

**We can SEE that 1% are defective**

$$\rightarrow P(\text{Defect}) = 1\%$$

**Out of all defective parts:**

**We can SEE that 50% came from mach1**

**And 50% came from mach2**

$$\rightarrow P(\text{Mach1} \mid \text{Defect}) = 50\%$$

**Question:**

**What is the probability that a part  
produced by mach2 is defective = ?**

**Mach1: 30 wrenches / hr**

**Mach2: 20 wrenches / hr**

$$\rightarrow P(\text{Mach1}) = 30/50 = 0.6$$

$$\rightarrow P(\text{Mach2}) = 20/50 = 0.4$$

**Out of all produced parts:**

**We can SEE that 1% are defective**

$$\rightarrow P(\text{Defect}) = 1\%$$

**Out of all defective parts:**

**We can SEE that 50% came from mach1**

**And 50% came from mach2**

$$\rightarrow P(\text{Mach1} \mid \text{Defect}) = 50\%$$

$$\rightarrow P(\text{Mach2} \mid \text{Defect}) = 50\%$$

**Question:**

**What is the probability that a part  
produced by mach2 is defective = ?**

**Mach1: 30 wrenches / hr**  
**Mach2: 20 wrenches / hr**

$$\rightarrow P(\text{Mach1}) = 30/50 = 0.6$$

$$\rightarrow P(\text{Mach2}) = 20/50 = 0.4$$

**Out of all produced parts:**  
**We can SEE that 1% are defective**

$$\rightarrow P(\text{Defect}) = 1\%$$

**Out of all defective parts:**  
**We can SEE that 50% came from mach1**  
**And 50% came from mach2**

$$\rightarrow P(\text{Mach1} \mid \text{Defect}) = 50\%$$

$$\rightarrow P(\text{Mach2} \mid \text{Defect}) = 50\%$$

**Question:**  
**What is the probability that a part**  
**produced by mach2 is defective = ?**

$$\rightarrow P(\text{Defect} \mid \text{Mach2}) = ?$$



**Mach1: 30 wrenches / hr**  
**Mach2: 20 wrenches / hr**

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**We can SEE that 1% are defective**

**Out of all defective parts:**  
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**Question:**  
**What is the probability that a part**  
**produced by mach2 is defective = ?**

~~$\rightarrow P(\text{Mach1}) = 30/50 = 0.6$~~

$\rightarrow P(\text{Mach2}) = 20/50 = 0.4$

$\rightarrow P(\text{Defect}) = 1\%$

~~$\rightarrow P(\text{Mach1} | \text{Defect}) = 50\%$~~

$\rightarrow P(\text{Mach2} | \text{Defect}) = 50\%$

$\rightarrow P(\text{Defect} | \text{Mach2}) = ?$

**Mach1: 30 wrenches / hr**

**Mach2: 20 wrenches / hr**

**Out of all produced parts:**

**We can SEE that 1% are defective**

**Out of all defective parts:**

**We can SEE that 50% came from mach1**

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**Question:**

**What is the probability that a part  
produced by mach2 is defective = ?**

$$\rightarrow P(\text{Mach2}) = 20/50 = 0.4$$

$$\rightarrow P(\text{Defect}) = 1\%$$

$$\rightarrow P(\text{Mach2} \mid \text{Defect}) = 50\%$$

$$\rightarrow P(\text{Defect} \mid \text{Mach2}) = ?$$

**Mach1: 30 wrenches / hr**

**Mach2: 20 wrenches / hr**

**Out of all produced parts:**

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**We can SEE that 50% came from mach1**

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**Question:**

**What is the probability that a part  
produced by mach2 is defective = ?**

$$\rightarrow P(\text{Mach2}) = 20/50 = 0.4$$

$$\rightarrow P(\text{Defect}) = 1\%$$

$$\rightarrow P(\text{Mach2} \mid \text{Defect}) = 50\%$$

$$\rightarrow P(\text{Defect} \mid \text{Mach2}) = ?$$

$$P(\text{Defect} \mid \text{Mach2}) = \frac{P(\text{Mach2} \mid \text{Defect}) \cdot P(\text{Defect})}{P(\text{Mach2})}$$



**Mach1: 30 wrenches / hr**

**Mach2: 20 wrenches / hr**

**Out of all produced parts:**

**We can SEE that 1% are defective**

**Out of all defective parts:**

**We can SEE that 50% came from mach1**

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**What is the probability that a part  
produced by mach2 is defective = ?**

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$$\rightarrow P(\text{Defect}) = 1\%$$

$$\rightarrow P(\text{Mach2} \mid \text{Defect}) = 50\%$$

$$\rightarrow P(\text{Defect} \mid \text{Mach2}) = ?$$

$$P(\text{Defect} \mid \text{Mach2}) = \frac{0.5 \cdot 0.01}{0.4}$$

**Mach1: 30 wrenches / hr**

**Mach2: 20 wrenches / hr**

**Out of all produced parts:**

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**We can SEE that 50% came from mach1**

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**What is the probability that a part  
produced by mach2 is defective = ?**

$$\rightarrow P(\text{Mach2}) = 20/50 = 0.4$$

$$\rightarrow P(\text{Defect}) = 1\%$$

$$\rightarrow P(\text{Mach2} \mid \text{Defect}) = 50\%$$

$$\rightarrow P(\text{Defect} \mid \text{Mach2}) = ?$$

$$P(\text{Defect} \mid \text{Mach2}) = \frac{0.5 \cdot 0.01}{0.4} = 0.0125$$

**Mach1: 30 wrenches / hr**

**Mach2: 20 wrenches / hr**

**Out of all produced parts:**

**We can SEE that 1% are defective**

**Out of all defective parts:**

**We can SEE that 50% came from mach1**

**And 50% came from mach2**

**Question:**

**What is the probability that a part  
produced by mach2 is defective = ?**

$$\rightarrow P(\text{Mach2}) = 20/50 = 0.4$$

$$\rightarrow P(\text{Defect}) = 1\%$$

$$\rightarrow P(\text{Mach2} \mid \text{Defect}) = 50\%$$

$$\rightarrow P(\text{Defect} \mid \text{Mach2}) = ?$$

$$P(\text{Defect} \mid \text{Mach2}) = \frac{0.5 \cdot 0.01}{0.4} = 0.0125 = 1.25\%$$



$$P(\text{Defect} \mid \text{Mach2}) = \frac{P(\text{Mach2} \mid \text{Defect}) * P(\text{Defect})}{P(\text{Mach2})} = 1.25\%$$



$$P(\text{Defect} \mid \text{Mach2}) = \frac{P(\text{Mach2} \mid \text{Defect}) * P(\text{Defect})}{P(\text{Mach2})} = 1.25\%$$

Let's look at an example:

- 1000 wrenches
- 400 came from Mach2
- 1% have a defect = 10

$$P(\text{Defect} \mid \text{Mach2}) = \frac{P(\text{Mach2} \mid \text{Defect}) * P(\text{Defect})}{P(\text{Mach2})} = 1.25\%$$

Let's look at an example:

- 1000 wrenches
- 400 came from Mach2
- 1% have a defect = 10
- of them 50% came from Mach2 = 5

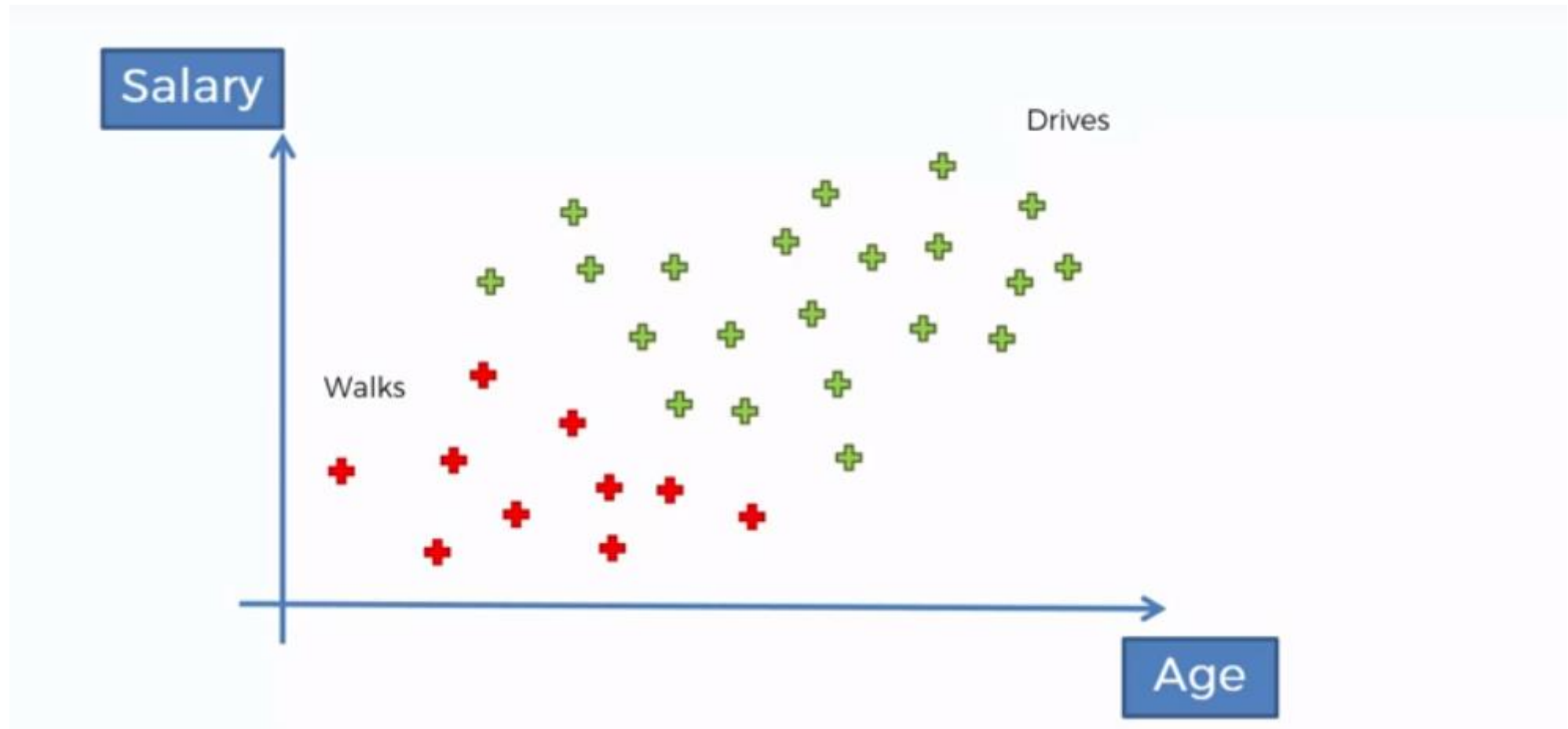
$$P(\text{Defect} \mid \text{Mach2}) = \frac{P(\text{Mach2} \mid \text{Defect}) \cdot P(\text{Defect})}{P(\text{Mach2})} = 1.25\%$$

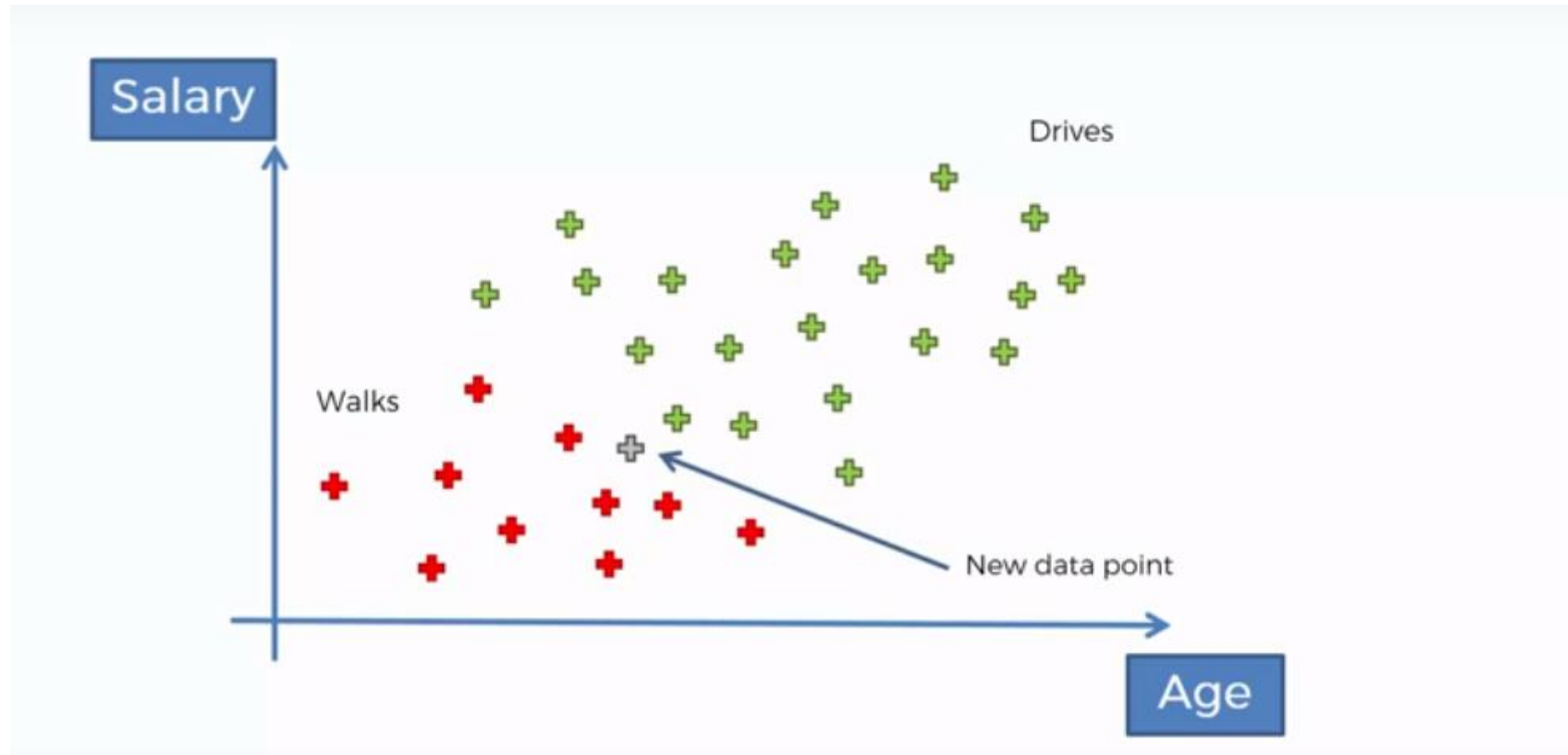
Let's look at an example:

- 1000 wrenches
- 400 came from Mach2
- 1% have a defect = 10
- of them 50% came from Mach2 = 5
- % defective parts from Mach2 =  $5/400 = 1.25\%$

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









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

#4

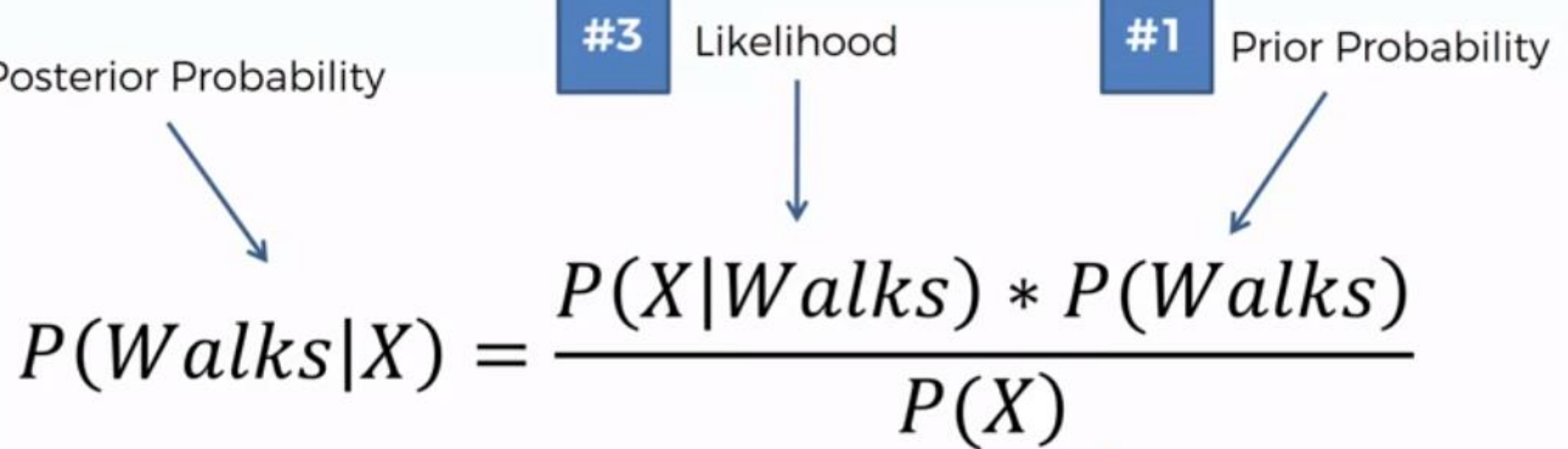
Posterior Probability

#3

Likelihood

#1

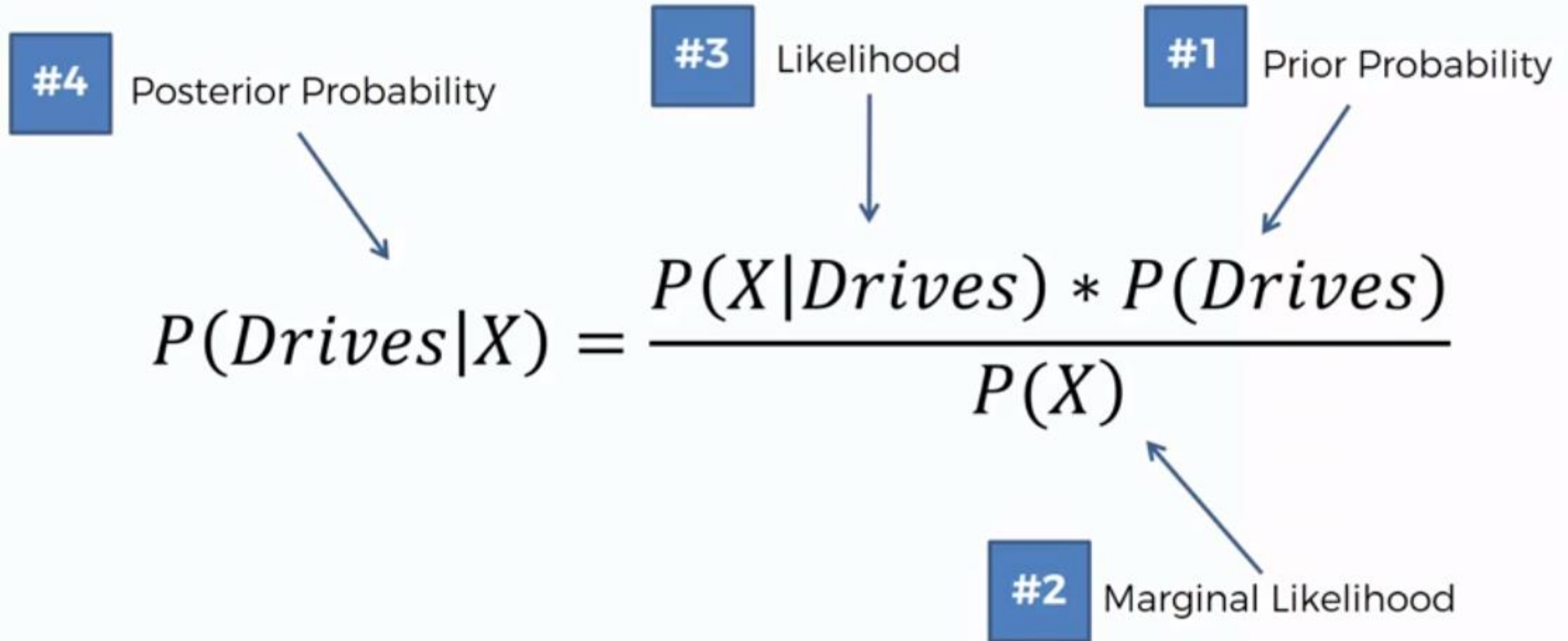
Prior Probability


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

#2

Marginal Likelihood

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



A diagram illustrating the components of Bayes' Theorem. The equation  $P(Drives|X) = \frac{P(X|Drives) * P(Drives)}{P(X)}$  is centered. Four blue boxes with white text are positioned around the equation, with arrows pointing to specific parts: #4 Posterior Probability points to the left side of the equation; #3 Likelihood points to the numerator's first term; #1 Prior Probability points to the numerator's second term; and #2 Marginal Likelihood points to the denominator.

#4 Posterior Probability

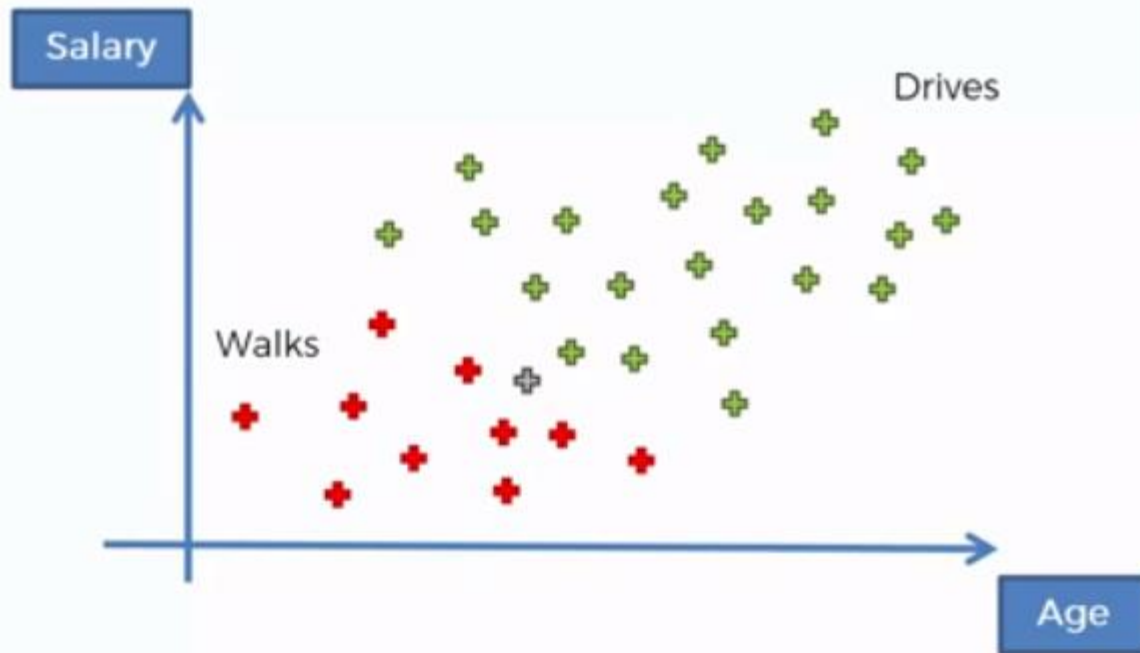
#3 Likelihood

#1 Prior Probability

#2 Marginal Likelihood

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

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



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

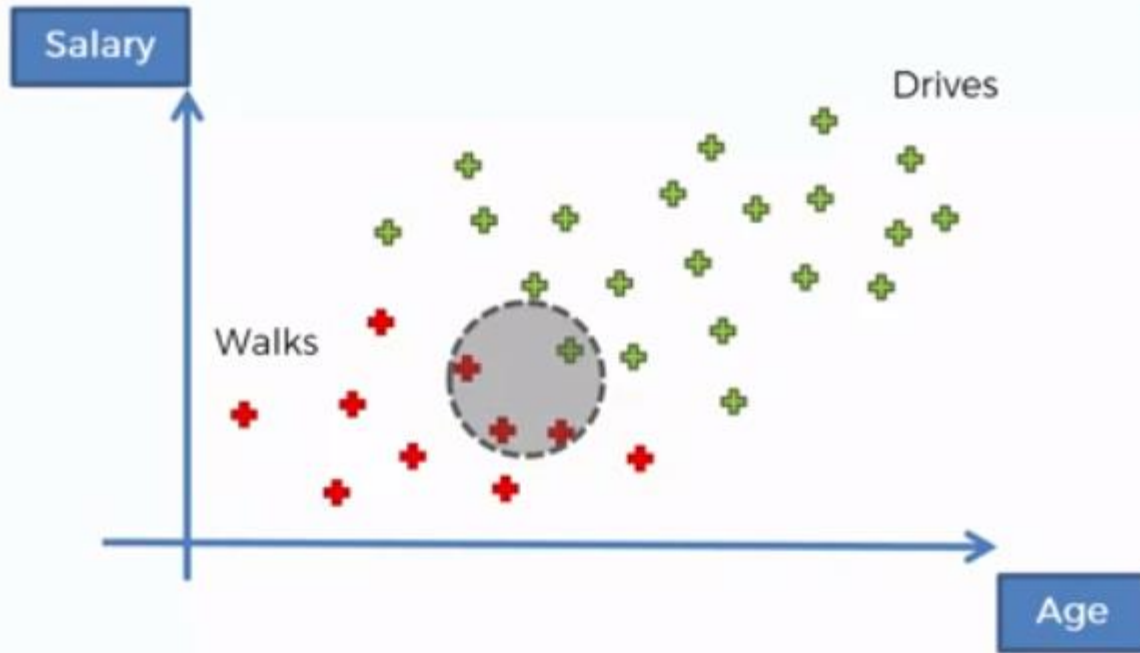
$$P(\text{Walks}) = \frac{\text{Number of Walkers}}{\text{Total Observations}}$$

$$P(\text{Walks}) = \frac{10}{30}$$

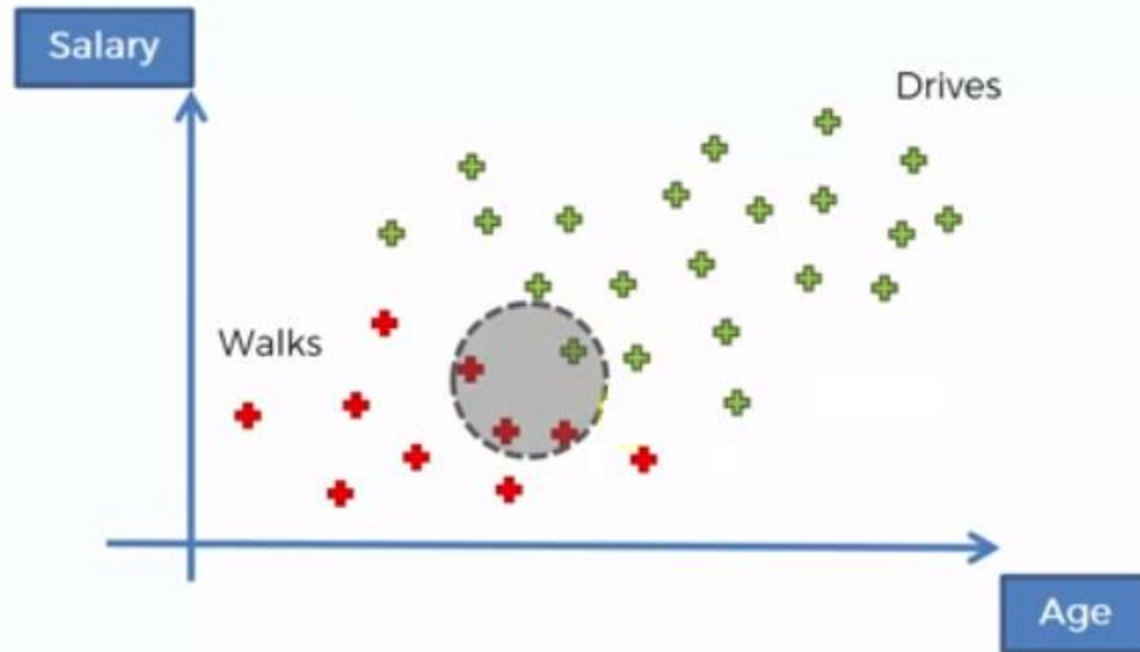
## #2. $P(X)$

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

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







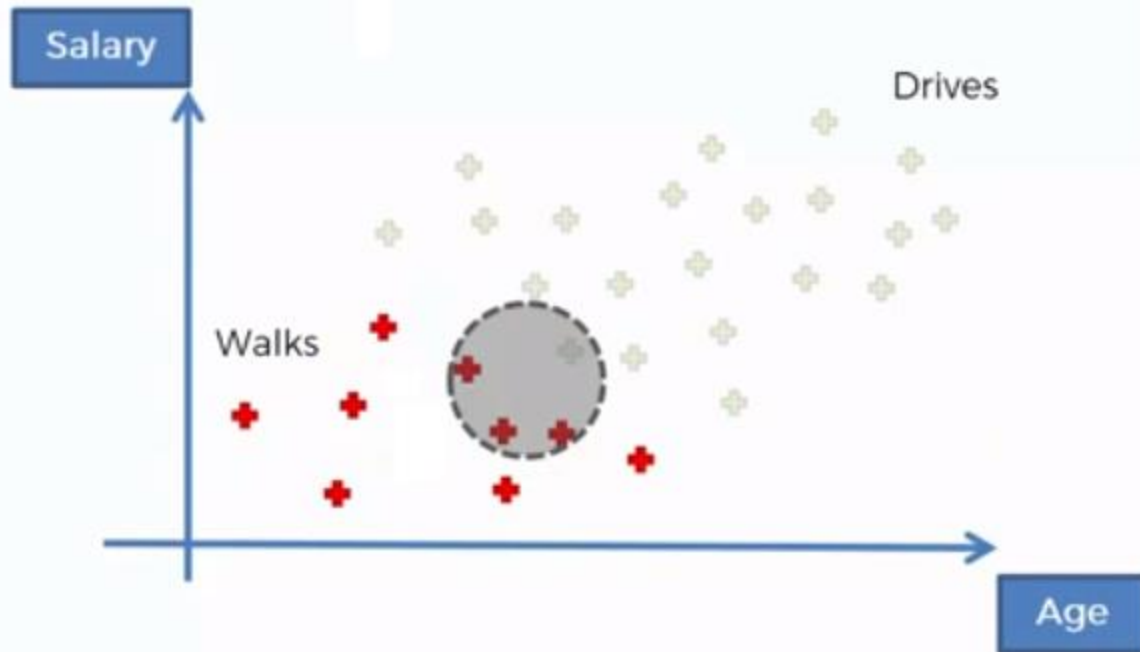
## #2. $P(X)$

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

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

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

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



#4

Posterior Probability

✓ #3

Likelihood

✓ #1

Prior Probability

$$P(Walks|X) = \frac{\frac{3}{10} * \frac{10}{30}}{\frac{4}{30}} = 0.75$$

✓ #2

Marginal Likelihood

#4

Posterior Probability

✓ #3

Likelihood

✓ #1

Prior Probability

$$P(Drives|X) = \frac{\frac{1}{20} * \frac{20}{30}}{\frac{4}{30}} = 0.25$$

✓ #2

Marginal Likelihood

$$0.75 > 0.25$$

$$P(Walks|X) > P(Drives|X)$$