
# UNCERTAINTY

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Till now, we have learned knowledge representation using propositional logic with certainty, which means we were sure about the predicates. With this knowledge representation, we might write $A \rightarrow B$, which means if A is true then B is true, but **consider a situation where we are not sure about whether A is true or not then we cannot express this statement, this situation is called uncertainty**.

So to represent uncertain knowledge, where we are not sure about the predicates, we need **uncertain reasoning** or **probabilistic reasoning.** https://www.javatpoint.com/probabilistic-reasoning-in-artifical-intelligence

UNCERTAINTY

# Uncertainty

- **Uncertainty** can be defined as a lack of enough information to make a decision.
- **Uncertainty** is a problem because it can prevent us from making the best decision possible.

# Uncertainty

- Many problems **cannot be completely and consistently modelled**.

  As an example:

  A type of reasoning in which new facts are introduced, resulting in inconsistencies that have the following characteristics:

  - Uncertainty exists.
  - There has been a shift in knowledge.
  - The addition of new facts can alter an already reached conclusion.

# Uncertainty

**Example :**

- Premise 1: Algebra is a difficult subject.
- Premise 2: Geometry is a difficult subject.
- Premise 3: Calculus is a difficult subject.
- **Conclusion**: Mathematics is a difficult subject.

# Uncertainty

The emergence of a new premise could lead to the failure of previously obtained conclusions, for example:

> **Premise 4**: Kinematics is a difficult subject.

The premise leads to the conclusion that **"Mathematics is a difficult subject,"** which is **incorrect** because kinematics is not a branch of mathematics, so there is potential for uncertainty when using inductive reasoning.

# Uncertainty

In the real world, **there are lots of scenarios, where the certainty of something is not confirmed**, such as "It will rain today," "behavior of someone for some situations," "A match between two teams or two players." These are **probable sentences for which we can assume that it will happen but not sure about i**t, so here **we use probabilistic reasoning**.

https://www.javatpoint.com/probabilistic-reasoning-in-artifical-intelligence

# Probability

Probability denotes the likelihood that something will occur or not.

**P(E) = the number of successful events / the total number of incidents**

**For example**, there are ten (10) scholars, three of whom are Cisco masters, so the opportunity to choose a bachelor comes from those who control Cisco:

**P(Cisco) = 3/10 = 0.3**

# Probability

$P(E) = 0$ -> Event E will not occur

$P(E) = 1$ -> Event E must occur

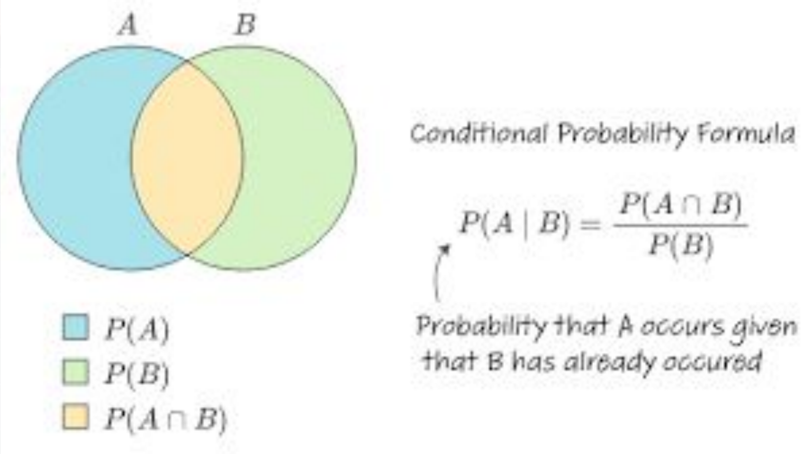
If $\bar{E}$ is not an event E, then $P(\bar{E}) = 1 - P(E)$ or $P(E) + P(\bar{E}) = 1$.

# Conditional Probability

"**Conditional probability refers to the chances of a particular event occurring, provided another event has previously occurred**. It is widely applicable in many areas, including business risk management, insurance, personal life, calculus, politics, etc., helping individuals and entities identify possible outcomes and make practical decisions accordingly."

https://www.wallstreetmojo.com/conditional-probability/#h-conditional-probability-definition

# Conditional Probability




**P(A|B)** denotes the conditional chance, i.e., the probability of the occurrence of event A with relation to condition B.

**P(A∩B)** signifies the joint probability of both events occurring. It is not what both the events cover individually but the common factor that connects both of them for the outcome.

**P(B)** is the probability of B.

https://stats.stackexchange.com/questions/587109/why-is-the-denominator-in-a-conditional-probability-the-probability-of-the-condi

https://www.wallstreetmojo.com/conditional-probability/#h-conditional-probability-definition

# Conditional Probability

**Example:**

➔ In a book fair attended by 300 people, 130 bought fiction books (F). Seventy people chose non-fiction books (N), while 100 visitors selected books from both genres. If a randomly chosen buyer bought a fiction book, what is the probability of the same person buying a non-fiction book too?

# Conditional Probability

**Solution**

Probability of people choosing fiction books, i.e., P(F) = 130/300 = 0.43

Probability of people choosing fiction and non-fiction books, i.e., P(N∩F) = 100/300 = 0.33

Probability of a random person with fiction books also choosing non-fiction, i.e.,

Probability of a random person with fiction books also choosing non-fiction, i.e.,

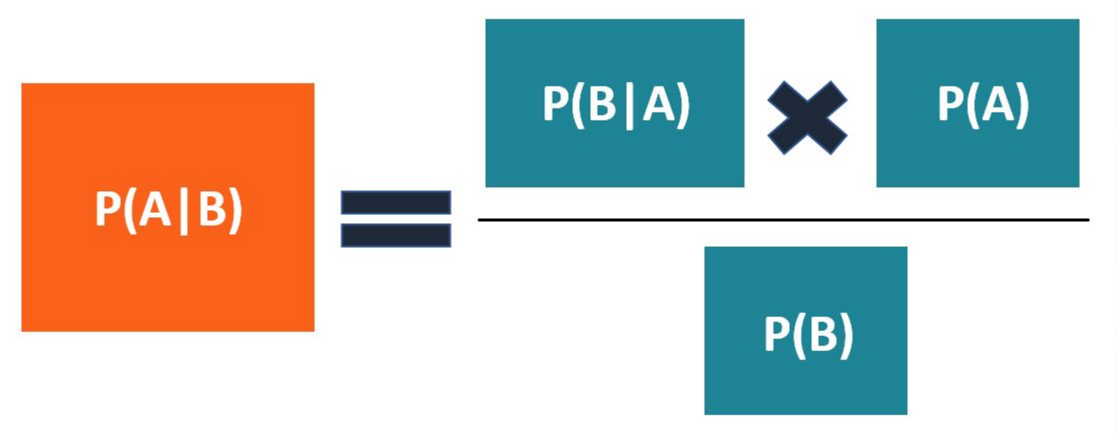
$$P(N|F) = P(F\cap N)/P(F) = 0.33/0.43$$
$$= 0.767 = 0.8 \text{ (approx.)}$$

Therefore, the probability of a random buyer choosing non-fiction books given they have already purchased a fiction book is 80%.

# Bayes' Theorem

The theorem is named after English statistician, Thomas Bayes, who discovered the formula in 1763. It is considered the foundation of the special statistical inference approach called the Bayes’ inference.

https://corporatefinanceinstitute.com/resources/data-science/bayes-theorem/



# Bayes' Theorem

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

- P(A|B) – the probability of event A occurring, given event B has occurred
- P(B|A) – the probability of event B occurring, given event A has occurred
- P(A) – the probability of event A
- P(B) – the probability of event B

Note that events A and B are independent events (i.e., the probability of the outcome of event A does not depend on the probability of the outcome of event B). → **Naive Bayes**

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# Bayes' Theorem

A special case of the Bayes' theorem is when event A is a binary variable. In such a case, the theorem is expressed in the following way:

$$P(A|B) = \frac{P(B|A)P(A)}{P(B|A^-)P(A^-) + P(B|A^+)P(A^+)}$$

Where:

P(B|A–) : the probability of event B occurring given that event A– has occurred

P(B|A+) : the probability of event B occurring given that event A+ has occurred

In the special case above, events A– and A+ are mutually exclusive outcomes of event A

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# Difference Between Conditional Probability and Bayes' Theorem

| **Conditional Probability** | **Bayes Theorem** |
|---|---|
| Conditional Probability is the probability of an event A that is based on the occurrence of another event B. | Bayes Theorem is derived using the definition of conditional probability. The Bayes theorem formula includes two conditional probabilities. |
| Formula: $P(A\|B) = \frac{P(A \cap B)}{P(B)}$ | Formula: $P(A\|B) = \frac{P(B\|A)P(A)}{P(B)}$ |

https://www.cuemath.com/data/bayes-theorem/

# Bayes' Theorem

**Example :**

Here, “being an alcoholic” is the “test” (type of litmus test) for liver disease. As per earlier records of the clinic, it states that 10% of the patient’s entering the clinic are suffering from liver disease. Earlier records of the clinic showed that 5% of the patients entering the clinic are alcoholic. Also,  7% out of the he patient’s that are diagnosed with liver disease, are alcoholics.

What is the probability of a patient having liver disease if they are alcoholic?

https://www.upgrad.com/

# Bayes' Theorem

## Solution :

**A** is the event i.e. “patient has liver disease”.

**P(A)**= 10% = 0.1

**B** is the litmus test that “Patient is an alcoholic”.

**P(B)**= 5% = 0.05

**P(B|A)**: probability of a patient being alcoholic, given that they have a liver disease

**P(B|A)**: 7% =0.07

probability of a patient having liver disease if they are alcoholic = **P(A|B)**

**P(A|B)= (P(B|A)*P(A))/P(B)** = (0.07 * 0.1)/0.05 = 0.14

Therefore, for a patient being alcoholic, the chances of having a liver disease are 0.14 (14%).

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# THANKS!

## See You

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