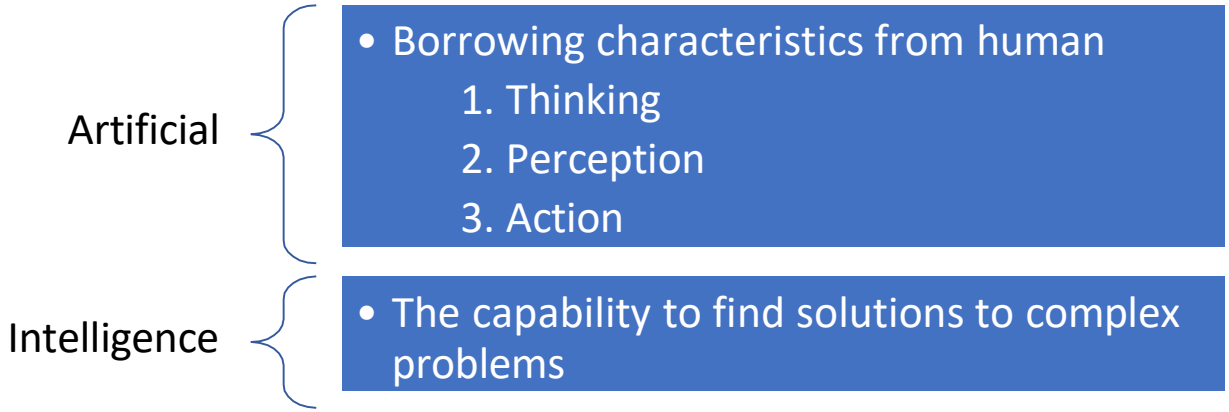
Lecture - 2

Cognitive Computing, Cognition, AI, NLP, ML, Big Data

Cognitive Computing - Introduction

- Cognitive Computing is a subset of **artificial intelligence (AI),** that aims to create systems capable of ***mimicking human-like cognitive functions.***



Cognition

Definition

- Cognition refers to the mental processes of acquiring knowledge and understanding through thought, experience, and the senses
- It involves activities like perception, learning, memory, reasoning, and problem-solving
- It is a biological and psychological process that happens in the human brain

Examples of Processes

- Understanding spoken or written language
- Solving problems and making decisions
- Recognizing patterns and interpreting emotions

Cognition

Goal

- To describe and understand how humans think and process information

Key Features

- Involves subjective, emotional, and intuitive elements
- Relates to consciousness and awareness

Cognition Vs Cognitive Computing

Aspect	Cognition	Cognitive Computing
Definition	Refers to **the mental processes** of acquiring knowledge and understanding through thought, experience, and the senses.	Refers to **technology systems** that simulate human thought processes. These systems use AI, Machine Learning (ML), Natural Language Processing (NLP), and other tools to mimic human cognition in analyzing data, reasoning, and decision-making.
Focus	How humans think and understand the world.	Simulating human-like thinking in machines.
Goal	To study and understand human thought.	To enhance decision-making and problem-solving through machines.
Examples	Human reasoning, perception, memory.	AI-driven systems like IBM Watson: answering questions in Jeopardy or assisting in medical diagnosis, chatbots.

Cognitive Computing - Goal

Goal

- Develop systems that can understand, interpret, and respond to complex information like the way humans do.
- Focuses on replicating human-like cognitive processes and emphasizes applications where human- machine collaboration is essential.
- AI, on the other hand, encompasses a broader set of technologies and techniques that aim to create intelligent systems capable of performing diverse tasks across various domains.

Human Intelligence vs AI

Human Intelligence vs Artificial Intelligence

Human Intelligence	Artificial Intelligence
Human intelligence functions on the basis of the surrounding environment.	Artificial intelligence functions on the basis of machine building. It copy's human behavior and create human-like functions.
Human brain functions according to memory, emotions, ability to think and computing power.	Artificial intelligence needs specific data and intelligence to function.
The ability to make decisions and take rational steps gets slowed down.	Artificial intelligence is a quick process. The ability to give result and take unbiased steps is quicker.
Human intelligence can make rational decisions.	Artificial intelligence fails to make rational decisions ending up in taking commands.
Human intelligence can have error while making mathematical calculations.	Artificial intelligence, on the other hand, provide very precise calculations.
Human brain can perform various functions at a time. They can think, process, and perform various functions at a same time.	Although very quick, AI still lacks behind in the process of multitasking. Every process takes its own time. Even though it is very less, the artificial intelligence does not perform multitasking.

AI vs Cognitive Computing

Aspect	AI	Cognitive Computing
Definition	Focuses on building systems that **replace human intelligence** for automating tasks and decision-making.	Focuses on building systems that **augment/assist human intelligence**, helping humans make better decisions.
Purpose	**Automate tasks and make decisions independently,** often replacing human involvement.	**Augment human decision-making** by providing tools that mimic human thought processes.
Approach	Works **autonomously** to solve problems.	**Collaborates** with humans to assist in problem-solving.
Technology	Machine Learning, Natural Language Processing, Neural Networks, Deep Learning	ML, Natural Language Processing, Big Data Analytics, Neural Networks, Deep Learning, Sentiment Analysis
Interaction with humans	**Minimal or none**	**High**

AI vs Cognitive Computing

Aspect	**AI**	**Cognitive Computing**
Applications	Autonomous systems, such as robotics, self-driving cars (Tesla), and predictive analytics. - AI Powered chatbots like Siri, Alexa	Decision-support systems in industries like healthcare, finance, and education. - IBM Watson assisting doctors with diagnoses - Financial Decision Support Systems - Customer Service Improvement through NLP

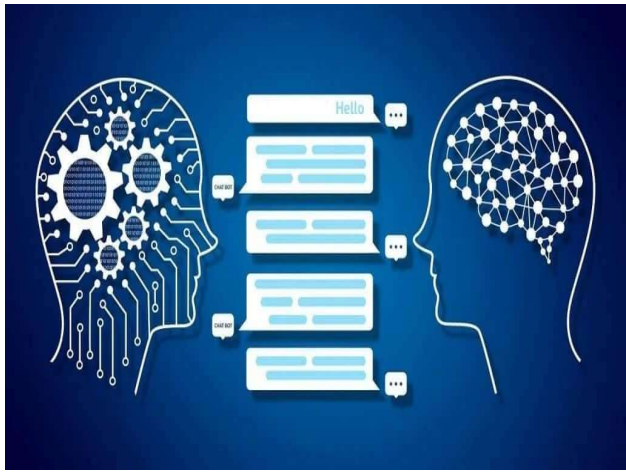
KEY DIFFERENCE: REPLACEMENT vs AUGMENTATION

SIMILARITY: Ability of machines to act, adapt, and reason based on experience it has learned

Foundation of Cognitive Computing

- Natural Language Processing (NLP)
- Machine Learning (ML)
- Big Data Analytics

Natural Language Processing (NLP)



Definition

- A field of AI that enables computers to understand and respond to human language

Key Techniques

- Tokenization

Breaking down text into smaller, manageable units, called tokens.

Word Tokenization:

Input: `"I love NLP!"`

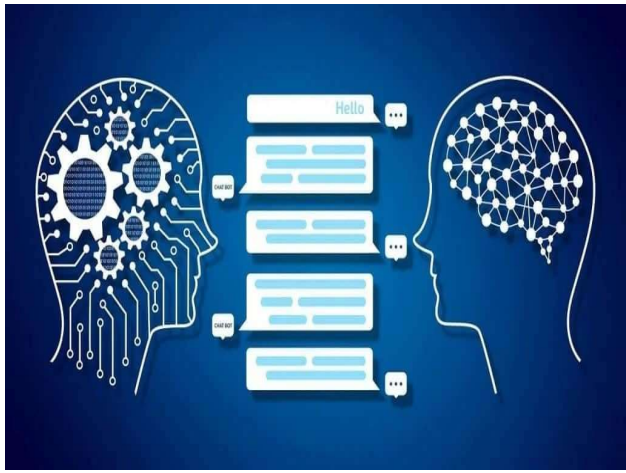
Output: `["I", "love", "NLP", "!"]`

Sentence Tokenization:

Input: `"Hello! How are you? I am fine."`

Output: `["Hello!", "How are you?", "I am fine."]`

Natural Language Processing (NLP)



Definition

- A field of AI that enables computers to understand and respond to human language

Key Techniques

- Parsing

Analyzing the grammatical structure of a sentence to understand the meaning

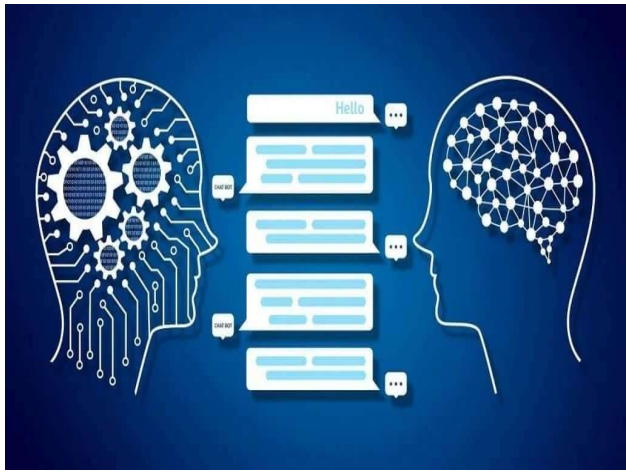
For the sentence "The cat sits on the mat.", parsing identifies:

Subject: "The cat"

Verb: "sits"

Prepositional phrase: "on the mat"

Natural Language Processing (NLP)



Definition

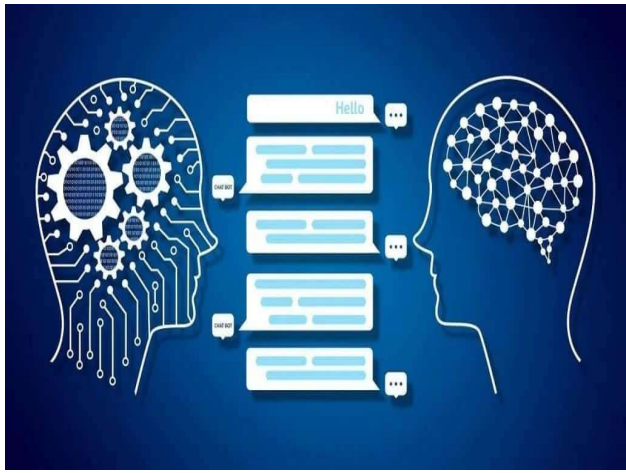
- A field of AI that enables computers to understand and respond to human language

Key Techniques

- Sentiment analysis

Also known as **opinion mining**
Used to determine the sentiment or emotion expressed in a piece of text

Natural Language Processing (NLP)



Applications

- Chatbots, language translation, smart assistants: voice assistants like Siri, Alexa.

Uses in Cognitive Computing

- It allows cognitive systems to interpret human language in all its complexity, enabling machines to understand spoken or written text much like a human listener or reader would.

Machine Learning (ML)

Definition

- A subset of AI focused on building systems that learn from data.

Types

- Supervised
- Unsupervised, and
- Reinforcement Learning

Machine Learning (ML)

Key Algorithms

- Decision trees, SVM, k-nearest neighbors, etc.

Applications:

- Image recognition, Email classification

Uses in Cognitive Computing:

- Equips systems with the ability to learn from data and experiences, much like humans learn from observation and interaction with the world.
- The more data these systems are exposed to, the more accurately they can make predictions or decisions.

Big Data Analytics

Definition

- A field that involves examining large and complex data sets to uncover hidden patterns, correlations, and insights, enabling data-driven decision-making.

Key Techniques

- Data mining, data visualization, predictive analytics, clustering, and real-time processing.

Big Data Analytics

Applications

- Fraud detection, recommendation systems, customer segmentation, healthcare diagnostics, financial risk analysis.

Uses in Cognitive Computing

- It enables cognitive systems to process and analyze massive volumes of **structured, unstructured and semi-structured data**, extracting meaningful insights to support reasoning, learning, and decision-making processes.

Structured data

- *Data that can be processed, stored, and retrieved in a fixed format.*
- *It refers to highly organized information that can be readily and seamlessly stored and accessed from a database by simple search engine algorithms.*
- *Example-The employee table in a company database will be structured as the employee details, their job positions, their salaries, etc., will be present in an organized manner.*

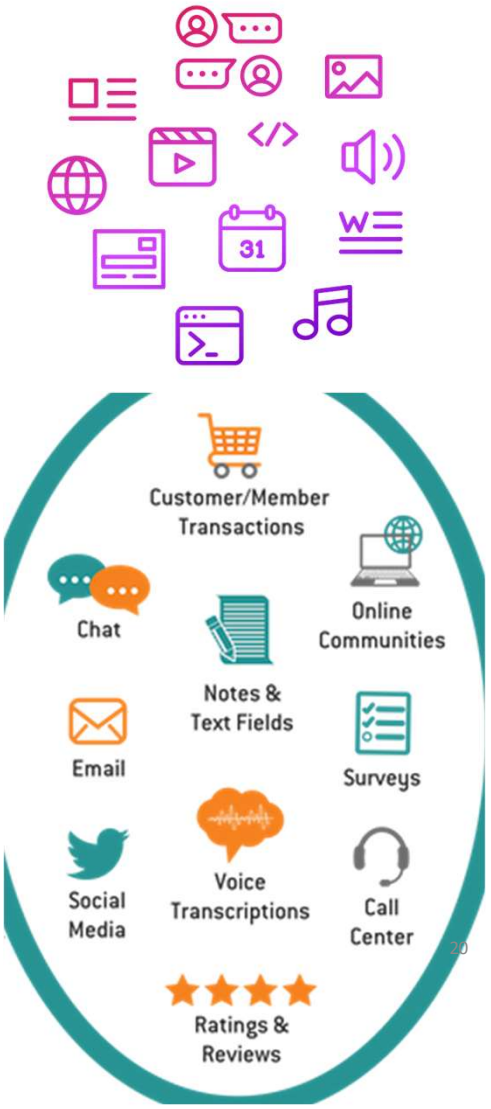
Table1 | Employeeinfo

ID	Name	F/Name	Position	Salary	Join date	Picture	Phone no	Address
1	Ajmal	Faraz	Manager	$3,000.00	1/2/2011	Package	435434	12, Z westren union bank str
2	Razaq	Ikbar	Driver	$1,000.00	5/2/2011	Package	532422	5, D avenue street
3	Moazzam	Nawaz	Security	$1,000.00	12/2/2011	Package	234235	3, D school road
4	Munir	Muhammad	Doctor	$2,500.00	1/4/2012	Package	436343	5,A national bank
5	Afzal	Faran	Security	$1,000.00	1/8/2012	Package	352464	9, D park road
6	Omair	Farhad	Cashier	$2,000.00	2/3/2012	Package	632345	13, Z Chinese restaurant
(New)								

Big Data Analytics

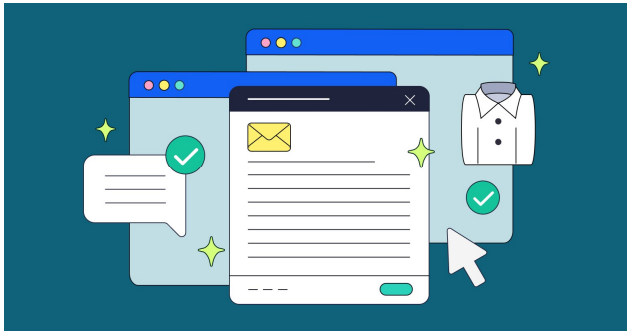
Unstructured data

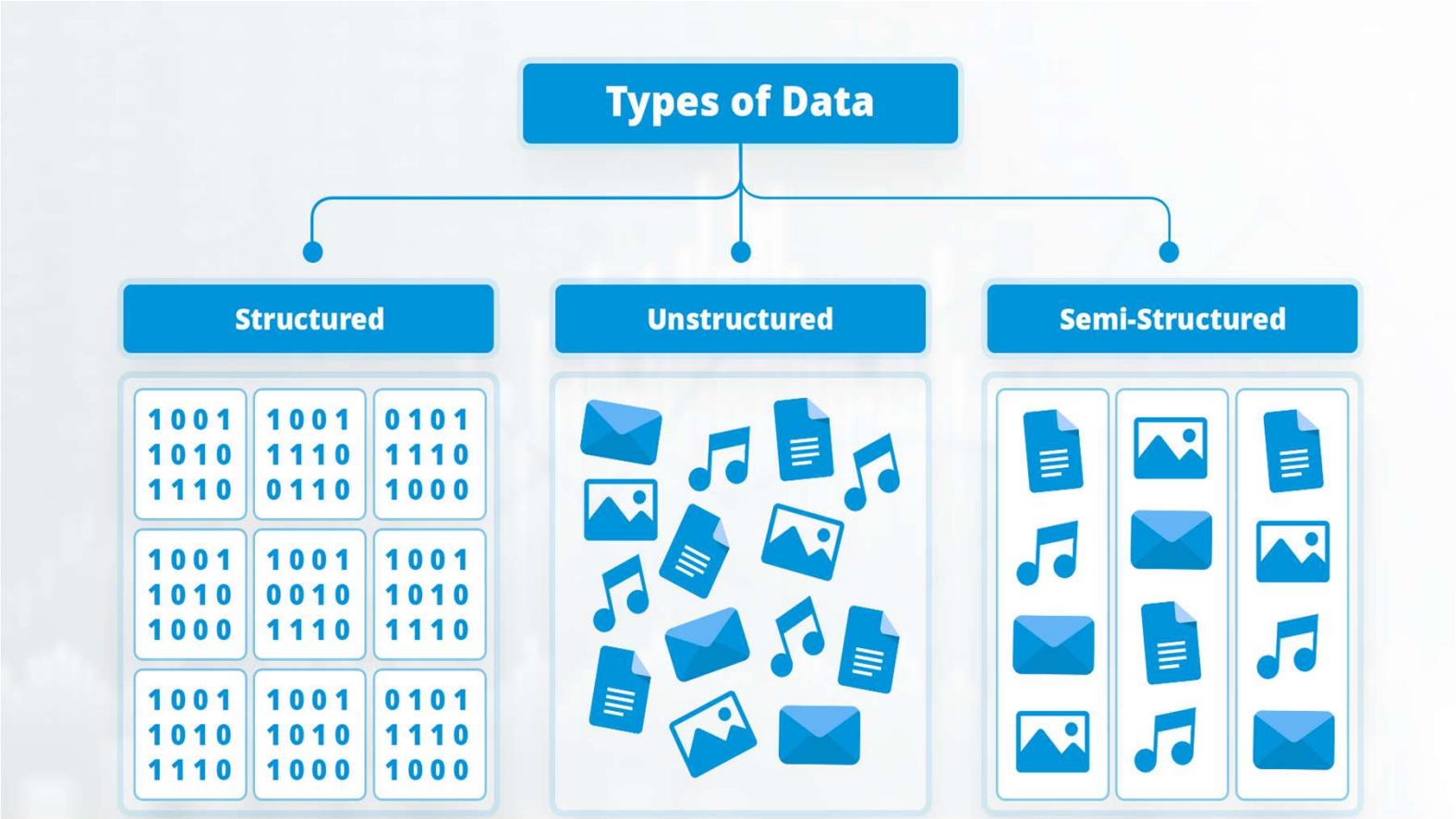
- *Refers to the data that lack any specific form or structure whatsoever.*
- *This makes it very difficult and time-consuming analyze unstructured data.*
- *Stored in data lakes, NoSQL (Not Only Structured Query Language) databases, or cloud-based systems.*
- *Free-form or undefined format (e.g., text, images, videos, audio).*



Semi-structured data

- *Pertains to the data containing both the formats mentioned above, that is, structured and unstructured data.*
- *To be precise, it refers to the data that although has not been classified under a particular repository (database), yet contains vital information or tags that segregate individual elements within the data.*
- *Example- Email*
  - *The written content of an email is unstructured, whereas the there are some inherent structure to the information in each email, such as the sender's name, recipient address, recipient name and date sent.*





Bank Transactions:
Fields: Transaction ID, Account Number, Date, Amount, Merchant Name.

Social Media Posts:
Facebook posts, tweets, Instagram captions, and hashtags.

Emails with Metadata:
The body is unstructured, but metadata like sender, receiver, subject, and timestamp is structured.

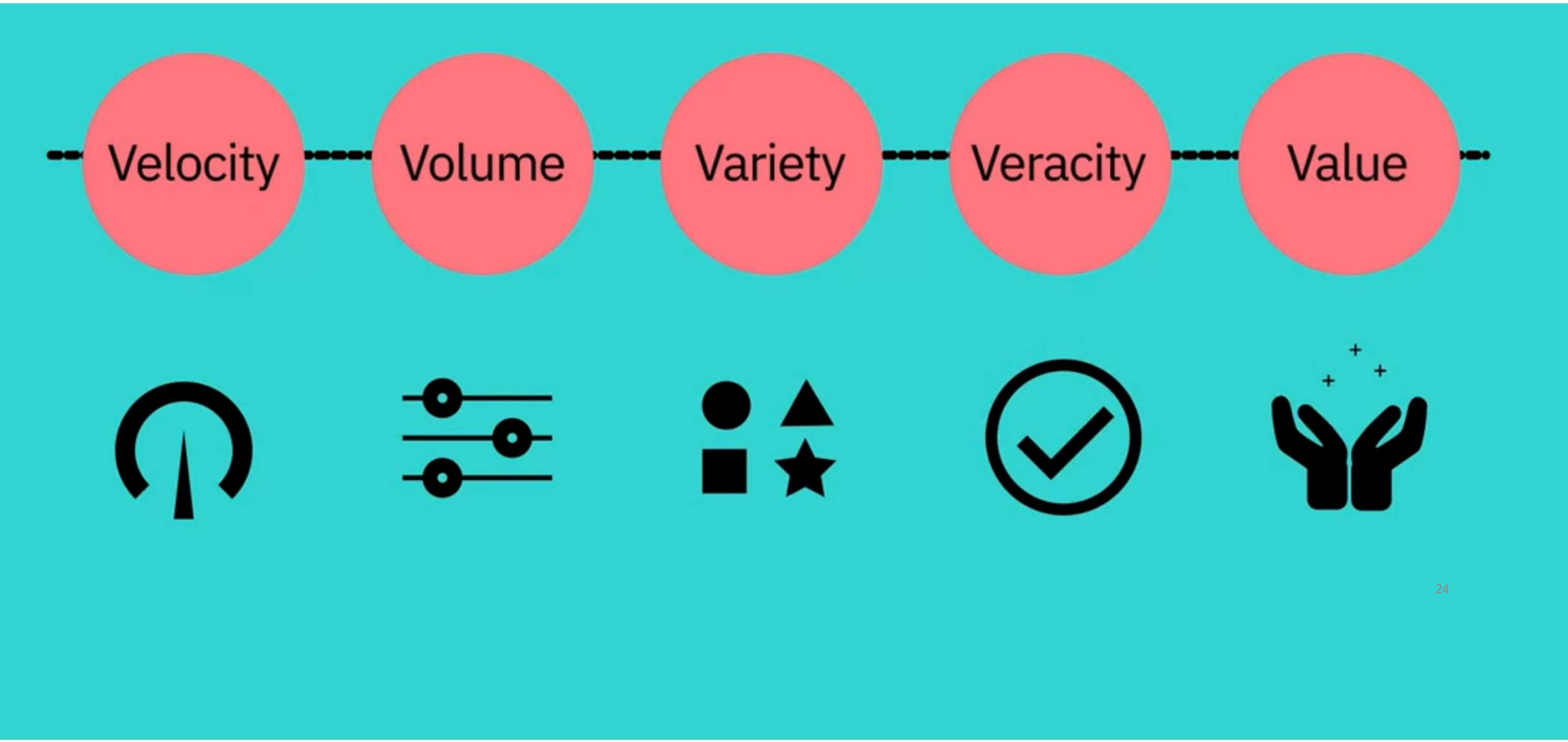
Big Data

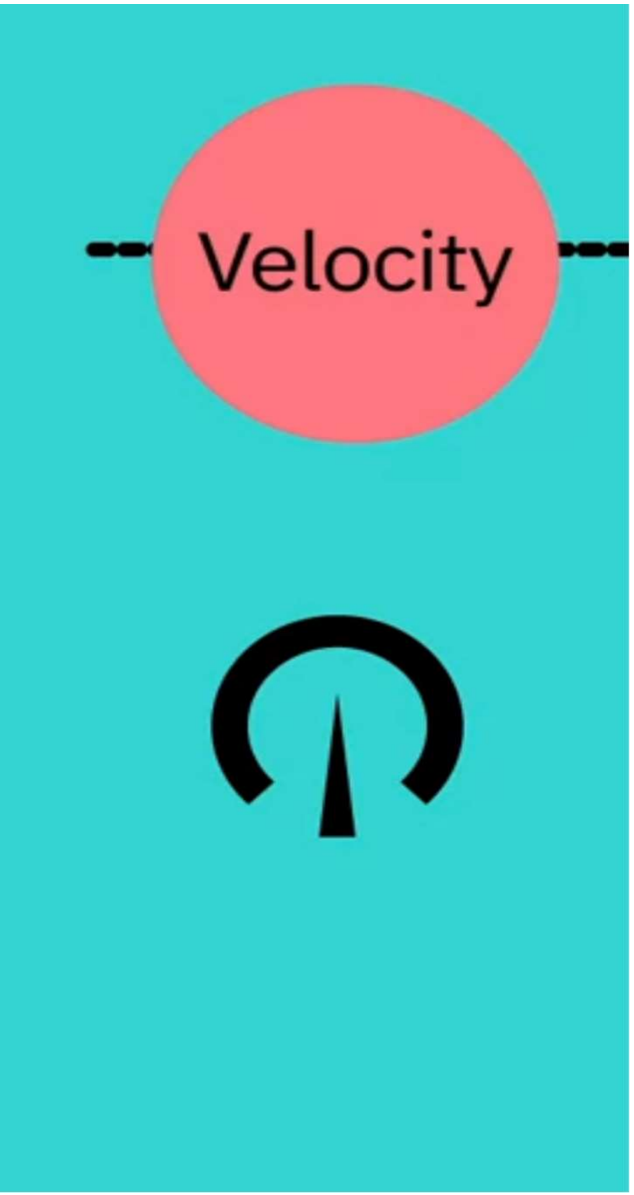
Definition

- Refers to the **dynamic, large and disparate volumes** of data being created by people, tools, and machines.
- It requires **new, innovative, and scalable technology** to collect, host, and analytically process the vast amount of data gathered in order to derive real-time business insights that relate to consumers, risk, profit, performance, productivity management, and enhanced shareholder value. - Ernst & Young

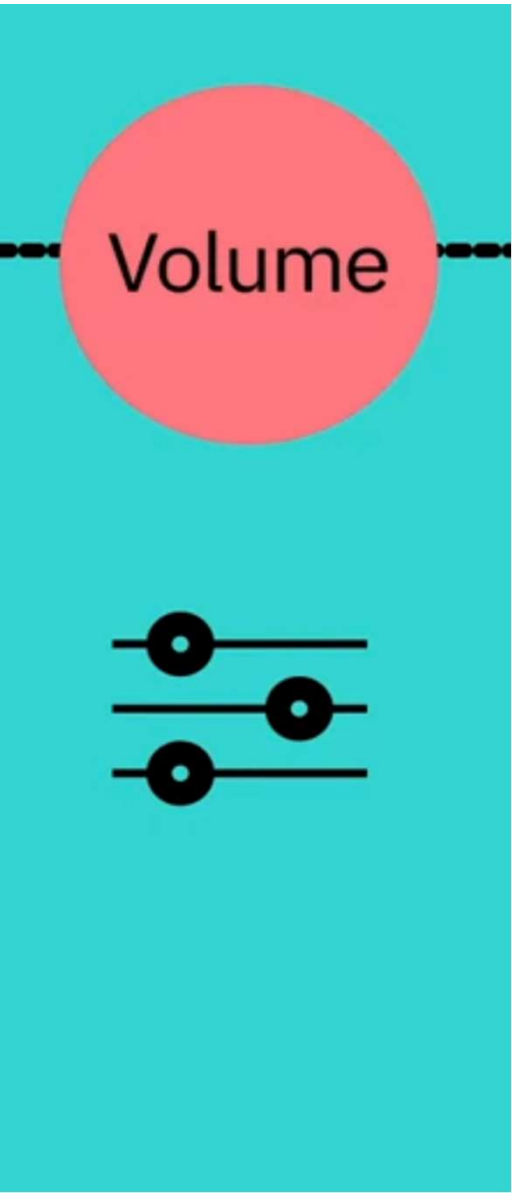
All definitions have 5 common characteristics

Characteristics of Big Data – 5Vs

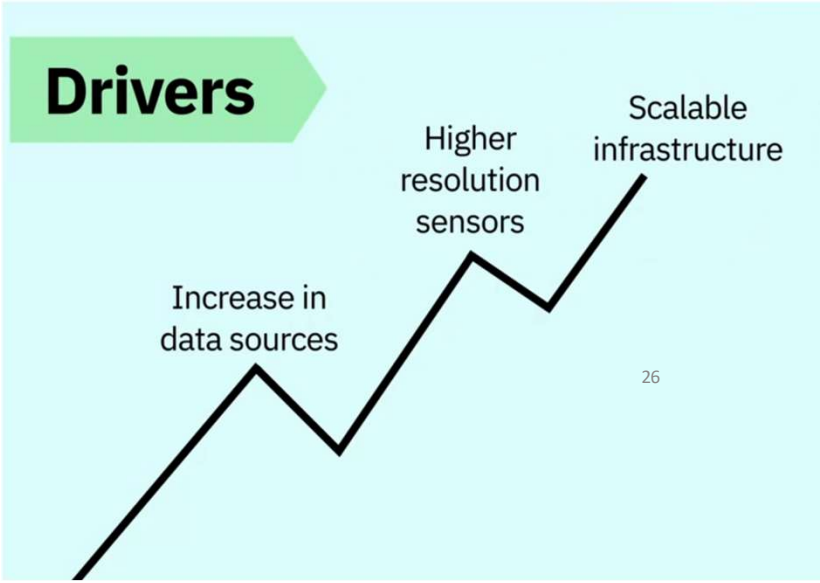




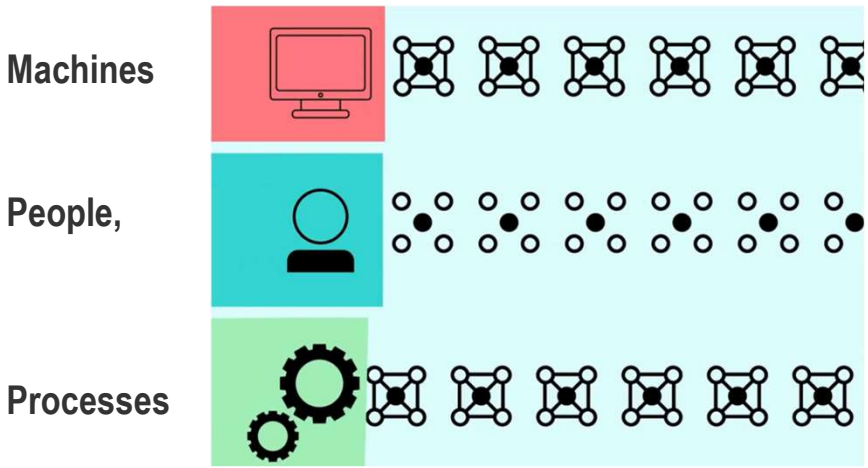
- **Velocity is the speed at which data is being created in real time.**
- **Data is being generated extremely fast, in a process that never stops**
- **Near or real-time streaming, local, and cloud-based technologies can process information very quickly**

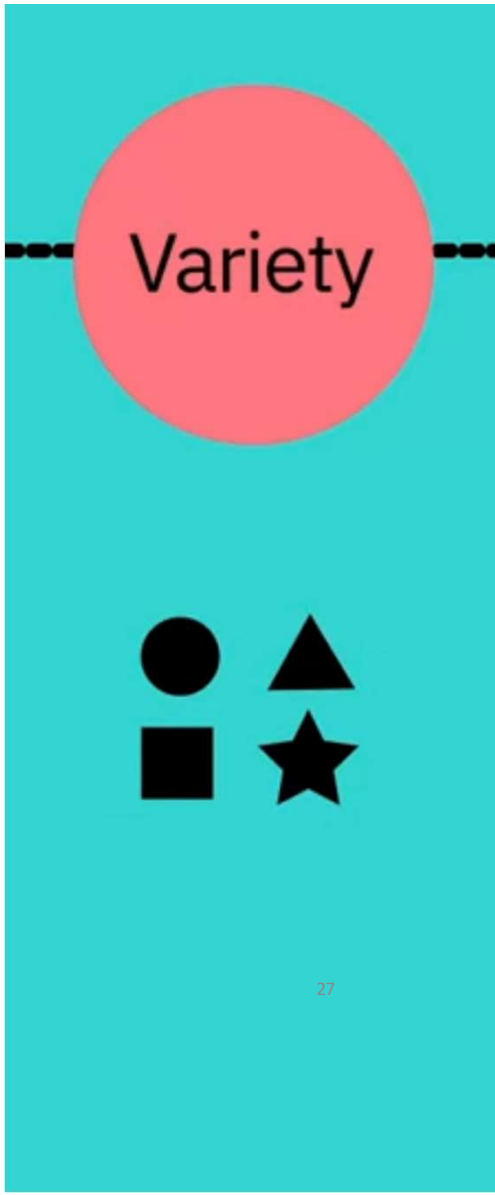


- **Volume is the scale of the data, or the increase in the amount of data stored.**
- **Drivers of volume are the increase in data sources, higher resolution sensors, and scalable infrastructure**
- **A large amount of data is stored in data warehouses.**

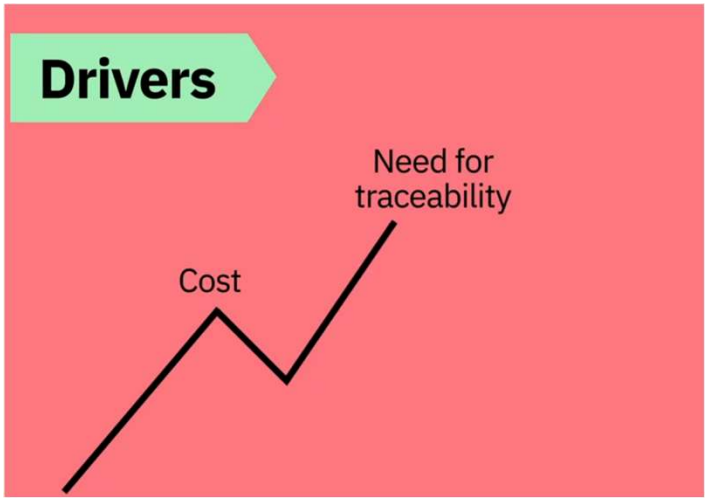


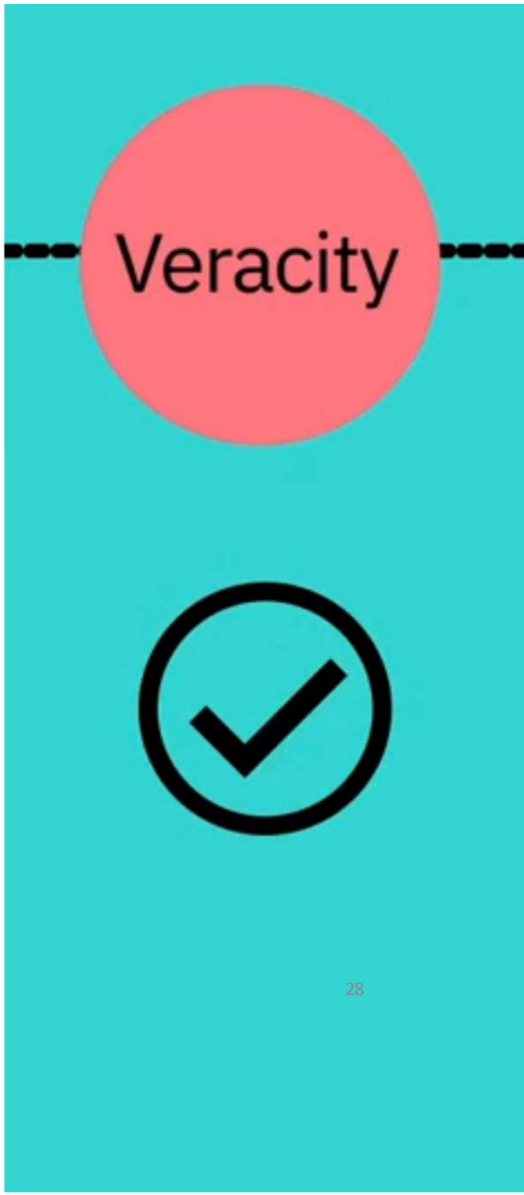
- Variety is the diversity of the data.
- Structured data fits neatly into rows and columns, in relational databases while unstructured data is not organized in a pre-defined way, like Tweets, blog posts, pictures, numbers, and video.
- Variety also reflects that data comes from different sources, machines, people, and processes, both internal and external to organizations.
- Drivers are mobile technologies, social media, wearable technologies, geo technologies, video, and many, many more.

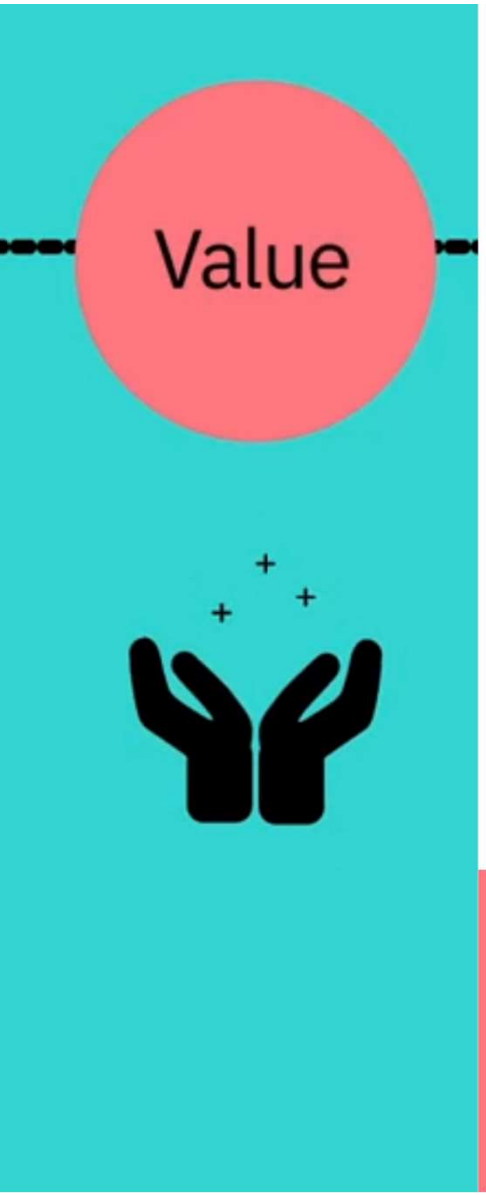




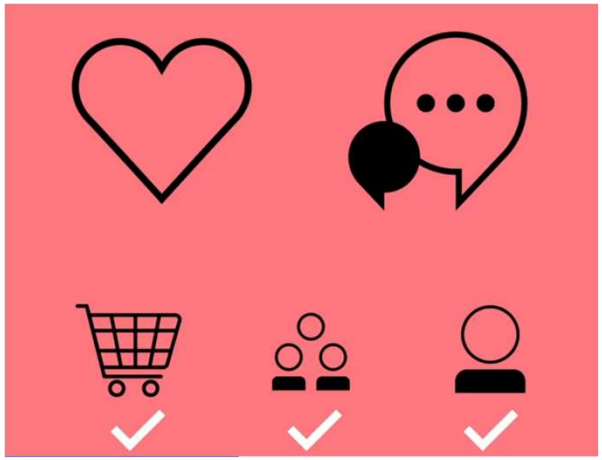
- Veracity is the quality and origin of data, and its conformity to facts and accuracy.
- Attributes include consistency, completeness, integrity, and ambiguity.
- Drivers include cost and the need for traceability.
- With the large amount of data available, the debate rages on about the accuracy of data in the digital age.
- Is the information real, or is it false?



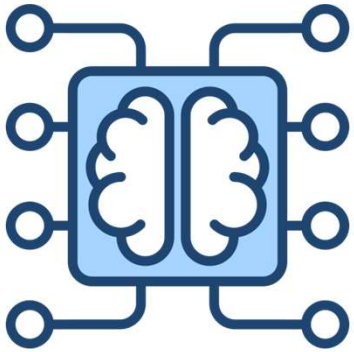




- Value is our ability and need to turn data into value.
- Value isn't just profit.
- It may have medical or social benefits, as well as customer, employee, or personal satisfaction.
- The main reason that people invest time to understand Big Data is to derive value from it.

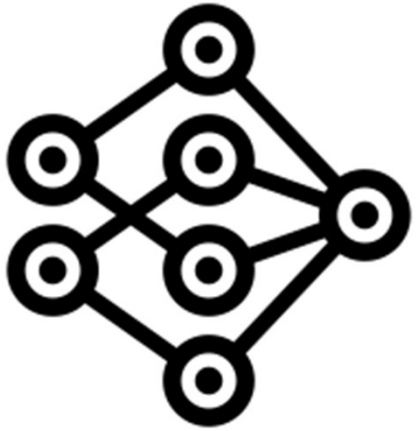


Fundamental Principles of Cognitive Computing



Learn

Gathering and understanding data



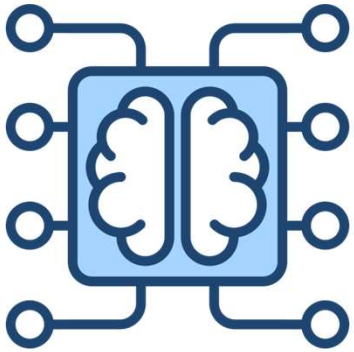
Model

Organizing data into a useful structure

Generate Hypotheses

Proposing and testing possible solutions

Fundamental Principles of Cognitive Computing

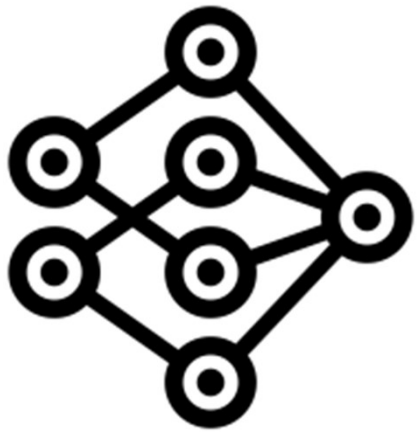


Learn

- A cognitive system learns from data.
- The system leverages data to make inferences about a domain, a topic, a person, or an issue based on training and observations from all varieties, volumes, and velocity of data.

Fundamental Principles of Cognitive Computing

- To learn, the system needs to create a model or representation of a domain (which includes internal and potentially external data) and assumptions that dictate what learning algorithms are used



Fundamental Principles of Cognitive Computing

Generate Hypotheses

- **The hypothesis** is defined as the supposition or proposed explanation based on insufficient evidence or assumptions
- It is just a guess based on some known facts but has not yet been proven.
- A good hypothesis is testable, which results in either true or false.
- Example:
  - Some scientist claims that ultraviolet (UV) light can damage the eyes then it may also cause blindness.
  - In this example, a scientist just claims that UV rays are harmful to the eyes, but we assume they may cause blindness.
  - However, it may or may not be possible. Hence, these types of assumptions are called a hypothesis.

Fundamental Principles of Cognitive Computing

Generate Hypotheses

- **Generate Hypothesis-**
  - A cognitive system assumes that there is not a single correct answer.
  - The most appropriate answer is based on the data itself.
  - Therefore, a cognitive system is probabilistic.
  - A hypothesis is a candidate explanation for some of the data already understood.
  - A cognitive system uses the data to train, test, or score a hypothesis.