Cognitive Computing
UCS712

Fundamental Principles of Cognitive Computing

Quick Recap

1. Cognitive computing systems aim to replicate human _____ processes, enabling them to make decisions and interpret data like humans.

Answer- **Cognitive**

2. In context of NLP, the process of breaking down text into individual elements such as words or phrases is called _____.

Answer- **Tokenization**

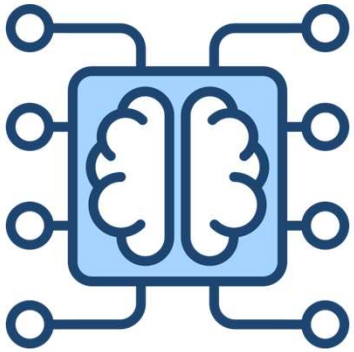
3. _____ learning uses rewards and punishments to learn the best strategies for solving a problem through trial and error.

Answer- **Reinforcement**

4. The _____ of big data refers to the large amount of data being generated and processed at high speeds.

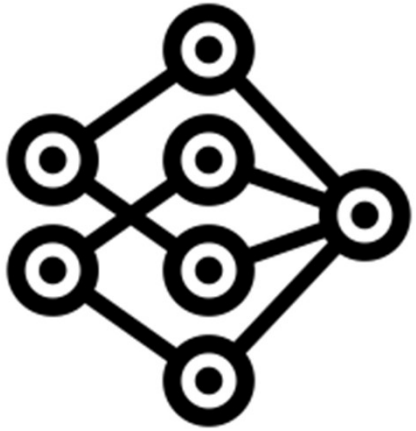
Answer- **Velocity**

Fundamental Principles of Cognitive Computing



Learn

Gathering and understanding data



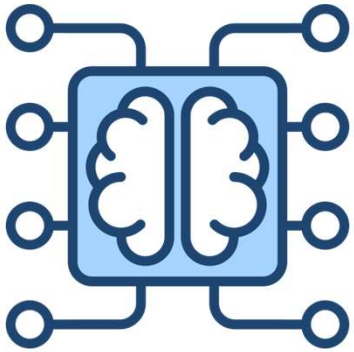
Model

Organizing data into a useful structure

Generate Hypotheses

Proposing and testing possible solutions

1. LEARN



Learn

Gathering and understanding data

- A cognitive system
  - *Learns from data*
  - *Analyzes various types of data to understand pattern, topic, behaviour*
    - *Structured/Unstructured*
    - *Big/Small*
  - ***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.*

Basic Example of Learning from Data

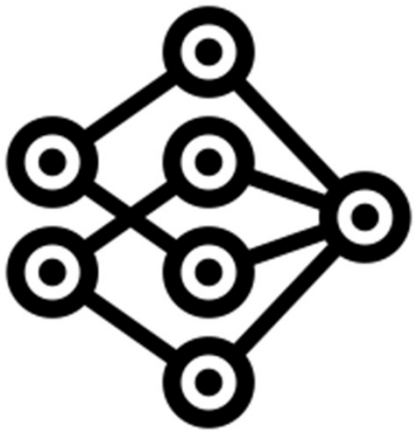
x	y
1	3
2	5
3	7
4	9
5	11

6	**?**	13
10	**?**	21

What did you learn about this data?

2. MODEL

- A cognitive system
  - *Create a Model or representation of domain (with internal and external data)*
  - ***Model***
    - *A structured way of representing the problem or domain it is analyzing.*
    - *Helps the system understand how data relates to real-world scenarios and guides the learning process.*



Model

Organizing data into a useful structure

Basic Example of Modeling Data

x	y
1	3
2	5
3	7
4	9
5	11
6	**13**
10	**21**

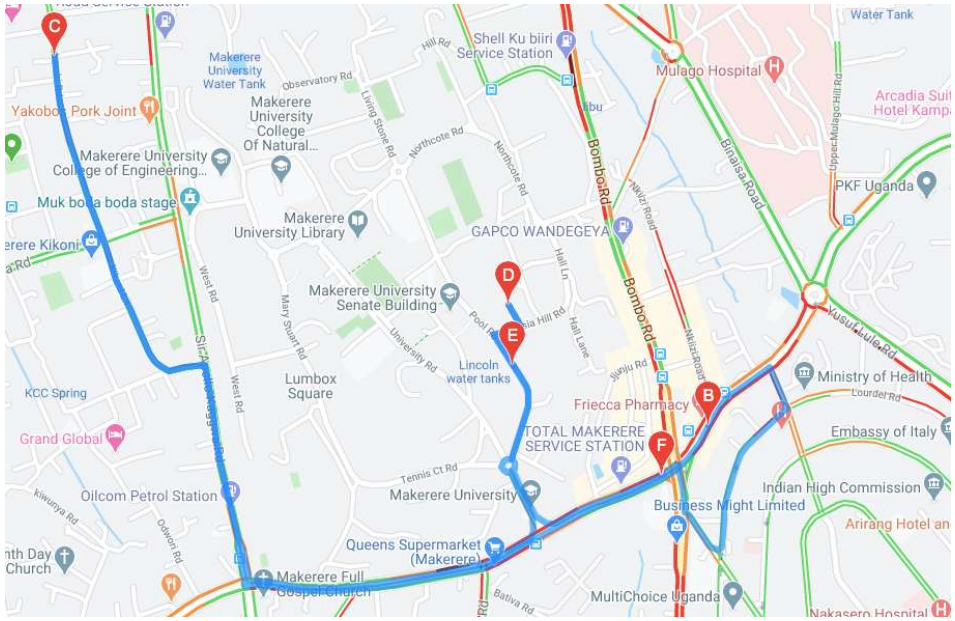
How will you model this data?

$$y = 2x + 1$$

Model = Not merely an equation, can have constraints, more than one equation, etc.

Real-Life Example – GOOGLE MAPS NAVIGATION

- Google Maps creates a model of the transportation network, including roads, traffic patterns, and user travel behavior.
- It uses this model to predict the fastest route to your destination.
- The model includes internal data (road layouts) and external data (real-time traffic updates).
- Context is key: the system considers whether you're walking, driving, or cycling to provide relevant routes.



3. GENERATE HYPOTHESIS

Generate Hypotheses

Proposing and testing possible solutions

- **The hypothesis**
  - *Proposed Solution to a particular problem*
  - *Defined as the supposition or proposed explanation based on insufficient evidence or assumptions*
  - *It is just an educated 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 of Hypothesis

- **Medical Diagnosis with IBM Watson:**
  When doctors input symptoms into IBM Watson, the system generates multiple hypotheses about possible diseases.
- It then analyzes medical data and assigns probabilities to each hypothesis, suggesting the most likely diagnosis.
- If the symptoms are "fever and sore throat," Watson might hypothesize:
  - *Common cold (80% probability)*
  - *Flu (15% probability)*
  - *Strep throat (5% probability)*

Basic Example of Hypothesis Generation

x	y
1	3
2	5

How will you model this data?

Hypothesis 1

$y = 2x + 1$

Hypothesis 2

$y = x^2 + x + 1$

Probabilistic Problem 50%

With Additional data, model will check which hypothesis is true and which one is false

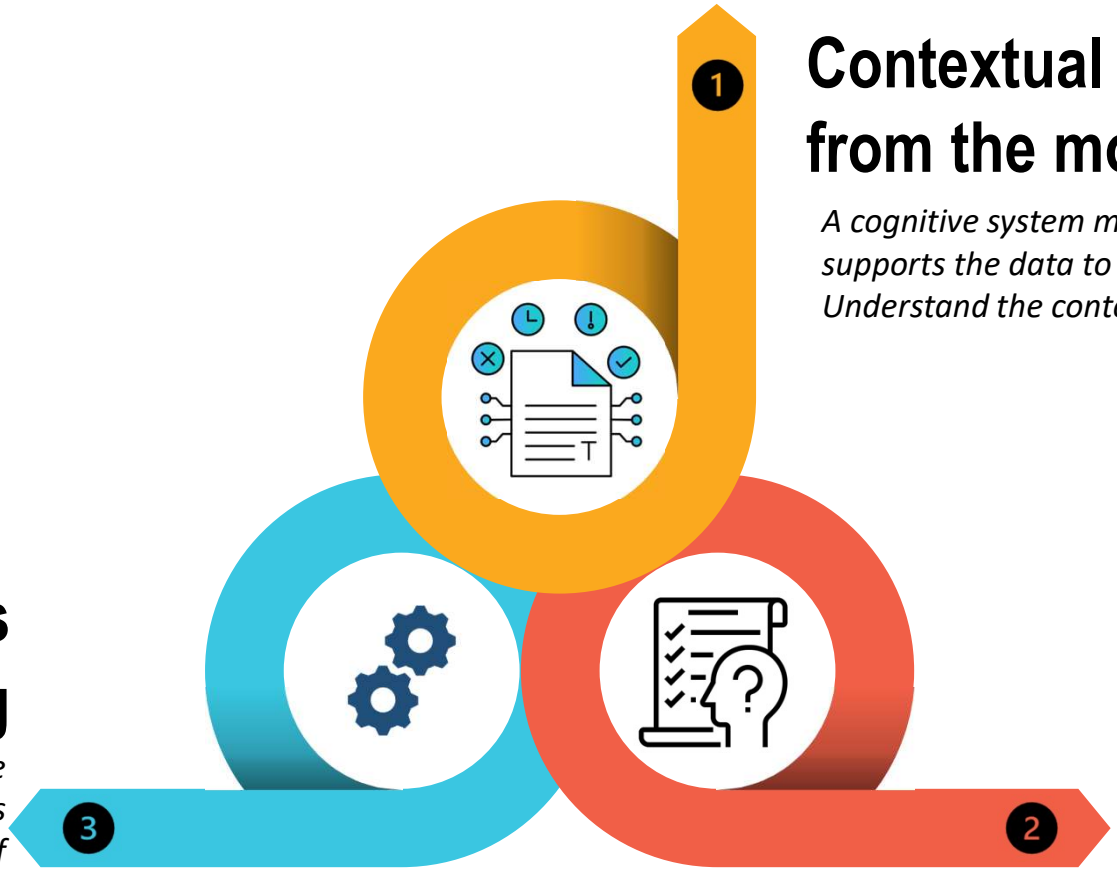
3. GENERATE HYPOTHESIS

Generate Hypotheses

Proposing and testing possible solutions

- **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.*

What Makes a System Cognitive?



Contextual insight from the model

A cognitive system must be aware of the context that supports the data to deliver value.
Understand the context surrounding data

Hypothesis Generation

Proposes possible explanations or predictions based on the data it processes.

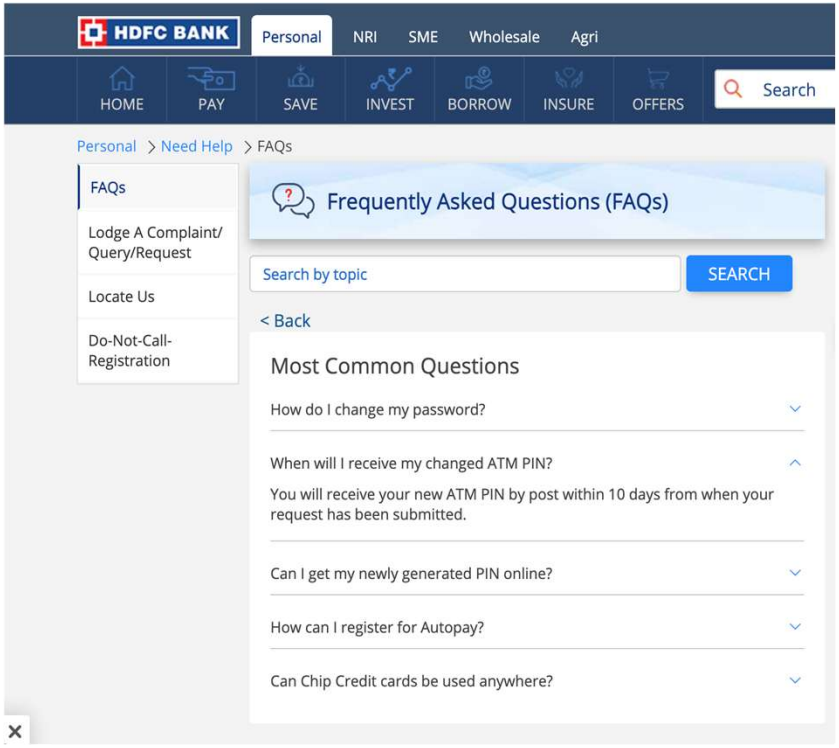
Continous Learning

Iterative process enables the system to learn and deepen its scope so that understanding of the data improves over time.

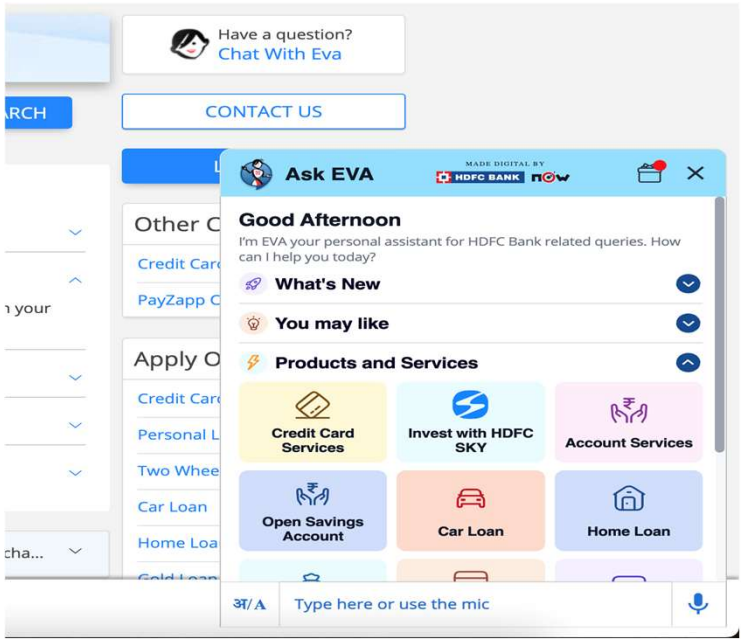
What Makes a System Cognitive?

- In practice, cognitive computing enables the examination of a wide variety of diverse types of data and the interpretation of that data to provide insights and recommend actions.
- The essence of cognitive computing is the acquisition and analysis of the right amount of information in context with the problem being addressed.
- One of the most **important practical characteristics** of a cognitive system is the *capability to provide the knowledge seeker with a series of alternative answers along with an explanation of the rationale or evidence supporting each answer.*

Example – Conventional Tech transformed to Cognitive Computing System



Customer support relied on static FAQ pages or scripted responses in call centers. Interactions were limited, manual, and often frustrating for users.



Cognitive chatbots like Banking Chatbots (HDFC Eva, SBI's YONO) now use NLP (Natural Language Processing) to understand user queries, respond in context, and adapt based on prior interactions. They can escalate unresolved issues or suggest personalized financial products.

Core Capabilities and Functionalities of Cognitive Systems

- **Learn from experience with data/evidence and improve its own knowledge and performance without reprogramming.**
- **Generate and/or evaluate conflicting hypotheses based on the current state of its knowledge.**
- **Report on findings in a way that justifies conclusions based on confidence in the evidence.**
- **Discover patterns in data, with or without explicit guidance from a user regarding the nature of the pattern.**
- **Emulate processes or structures found in natural learning systems (that is, memory management, knowledge organization processes, or modeling the neurosynaptic brain structures and processes).**
- **Use NLP to extract meaning from textual data and use deep learning tools to extract features from images, video, voice, and sensors.**
- **Use a variety of predictive analytics algorithms and statistical techniques.**

Domains Where Cognitive Computing Is Well Suited

Domains in which a single query or set of data may result in a hypothesis that yields **more than one possible answer.**

↓

Answers may not be mutually exclusive

↓

Such systems are called **Probabilistic** rather than *Deterministic*

Eg: Weather Forecasting

Predictions are given as probabilities, like a 60% chance of rain.

Probabilistic System

- In a probabilistic system, there may be a variety of answers, depending on circumstances or context and the confidence level or probability based on the system's current knowledge.
- Exact output is unknown
- E.g.
- Weather forecasting (Example: "There is a 70% chance of rain tomorrow." This means the system is confident in rain being the most likely outcome, but there is still a 30% chance it won't rain.)
- Item delivery (Example: "Your package is expected to arrive within 3–5 days." While this is a probabilistic estimate, exact timing depends on unforeseen circumstances.)

Deterministic System

- A deterministic system would have to return a single answer based on the evidence, or no answer if there were a condition of uncertainty
- Output is certain
- Relationships between inputs are known and certain
- E.g. Traditional form submissions, Calculators, Algorithmic systems (Search Engines, Recommendation systems)

Domains Where Cognitive Computing Is Well Suited

Domain is complex and conclusions depend on who is asking the question and the complexity of the data.

↓

Unlike traditional systems that rely on fixed algorithms, cognitive computing systems can process and understand unstructured data (e.g., natural language, images, or complex patterns) and adapt to dynamic environments.

↓

Ability to personalize responses based on the context of the question being asked

↓

Manage big data, including both structured and unstructured form