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Knowledge-based Agent

THE THEORY OF KNOWLEDGE

Knowledge is information about a domain of interest that can be used to solve problems in that domain..

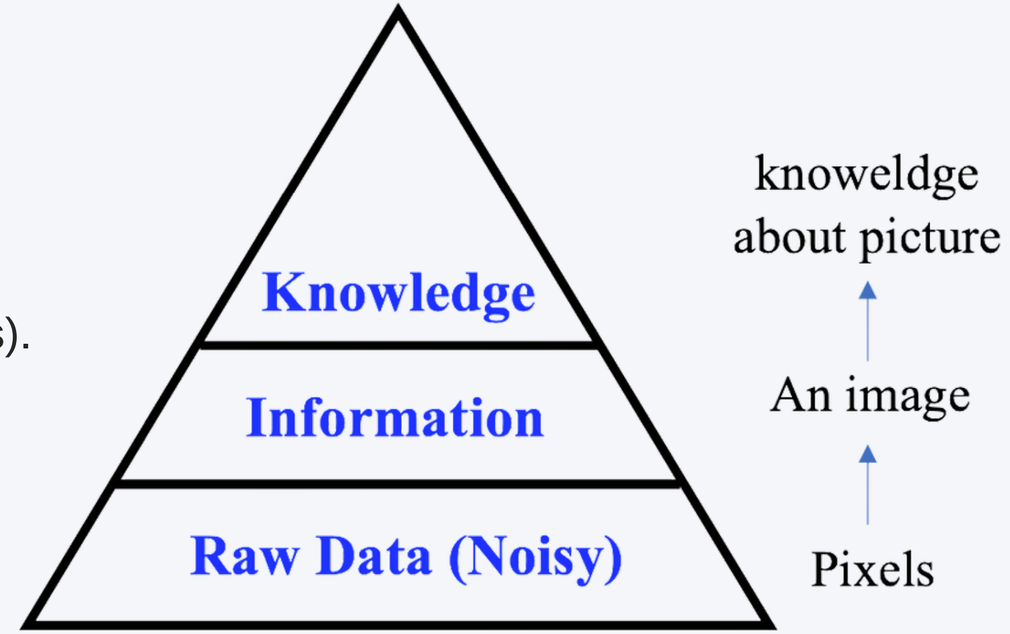
Solving a problem requires enough knowledge about it.

Framework of effective knowledge utilization:

1. Representing Knowledge (Knowledge Representation)
- Creating a formal representation or encoding of the world.:
- To make information computer-tractable (easy for a computer to process).

2. Using Knowledge (Reasoning, Inferencing, Planning)
- Using the encoded knowledge to draw conclusions or make decisions.
  - Apply logical rules or algorithms.
  - Derive new facts or solve problems.

3. Obtaining New Knowledge (Learning)
- Adding new information to the existing knowledge base.
- Allows the system to adapt and improve over time.

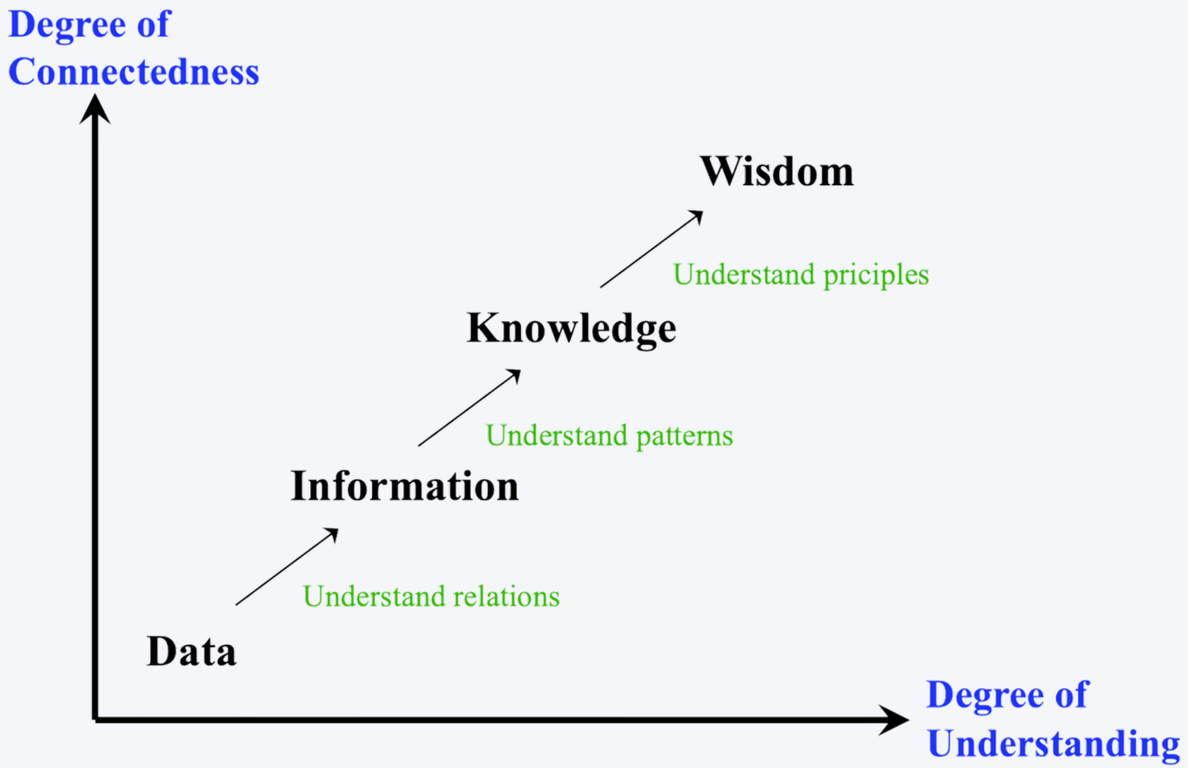


Hierarchy of Knowledge

Poole & Mackworth, 2010 (http://artint.info/slides/), and Russell & Norvig, 2005 (http://aima.cs.berkeley.edu/)

KNOWLEDGE MODEL (BELLINGER 1980)

- Knowledge Model (Bellinger 1980)



Poole & Mackworth, 2010 (http://artint.info/slides/), and Russell & Norvig, 2005 (http://aima.cs.berkeley.edu/)

BASIC TYPES OF KNOWLEDGE

1. Declarative Knowledge

Definition:

- Knowing WHAT something is.

Key Features:

- Explicit: Can be verbally or clearly articulated.
- Expressed in declarative statements, such as:
  - Facts
  - Concepts
  - Principles

Examples:

- "Paris is the capital of France."
- "Water boils at 100°C."

2. Procedural Knowledge

Definition:

- Knowing HOW to do something.

Key Features:

- Implicit: Often difficult to articulate verbally.
- Encoded as procedures or steps (e.g., code or workflows).

Examples:

- Riding a bike.
- Writing a computer program to sort data.

Poole & Mackworth, 2010 (http://artint.info/slides/), and Russell & Norvig, 2005 (http://aima.cs.berkeley.edu/)

KNOWLEDGE-BASED AGENT

Key Points About Agents:

- Agents Don’t Need to Be Sophisticated to Be Intelligent
  - An agent can be intelligent and useful even without physical interaction (e.g., robots).

- Limitations of Basic Agents
  - Agents from are not efficient or smart enough for complex environments.

- What Makes a Good Agent?

  - Needs **knowledge** about its environment to make better decisions.
  - Crucial in:
    - Partially Observable Environments
    - Dynamic Environments
    - Situations requiring new tasks

- **Knowledge-Based Agents**
  - Much of AI focuses on building knowledge-based systems and agents.

Poole & Mackworth, 2010 (http://artint.info/slides/), and Russell & Norvig, 2005 (http://aima.cs.berkeley.edu/)

GENERIC ARCHITECTURE OF KNOWLEDGE-BASED AGENTS

1. Knowledge Level

Definition:

- Describes what the agent knows and its goals.

Example:

  - Automated taxi driver knows:
  - "Riyadh East Ring links South region and North region."

2. Logical Level

Definition:

- Represents the agent's knowledge using logical sentences.

Example:

  - Knowledge Base contains:
  - Link(RUH_RING, S, N) (First-Order Logic representation).

3. Implementation Level

Definition:

- The implementation details, including functions and data structures.

Example:

  - The logical sentence Link(RUH_RING, S, N) is implemented as a C structure or a Prolog fact.

Poole & Mackworth, 2010 (http://artint.info/slides/), and Russell & Norvig, 2005 (http://aima.cs.berkeley.edu/)

Key Formula:

Autonomous Agent = Knowledge-Based Agent + Learning Mechanism

WHAT IS KNOWLEDGE REPRESENTATION

Why is KR Important?

- Problem-Solving Needs:
  - Large amounts of knowledge.
  - Mechanisms to manipulate that knowledge.

- Definition:
  - KR is a field of AI focused on representing the world in a computer-tractable form.
  - Enables AI agents to perform intelligent and rational tasks.

Knowledge vs. Representation

Knowledge:

- Describes the world.
- Determines a system’s competence by what it knows.

Representation:

- Encodes the knowledge.
- Affects the system’s performance in solving problems.

Poole & Mackworth, 2010 (http://artint.info/slides/), and Russell & Norvig, 2005 (http://aima.cs.berkeley.edu/)

WHAT IS KNOWLEDGE REPRESENTATION

Goals of KR for Intelligent Agents:

- Formal Representation:
  - Use a knowledge representation language to describe the world.
- Reasoning:
  - Make inferences using the representation.
- Action Selection:
  - Decide and evaluate actions based on the reasoning process.

Requirements of Effective Knowledge Representation

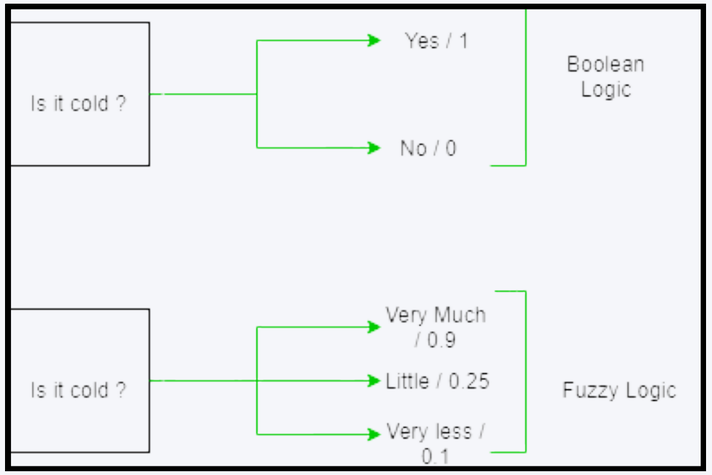
- Representational Adequacy:
  - Ability to represent all necessary knowledge for the domain.
- Inferential Adequacy:
  - Ability to manipulate knowledge to produce new insights.
- Inferential Efficiency:
  - Ability to efficiently update knowledge structures.
- Acquisitional Efficiency:
  - Ability to easily acquire new knowledge (e.g., automatic methods)

Poole & Mackworth, 2010 (http://artint.info/slides/), and Russell & Norvig, 2005 (http://aima.cs.berkeley.edu/)

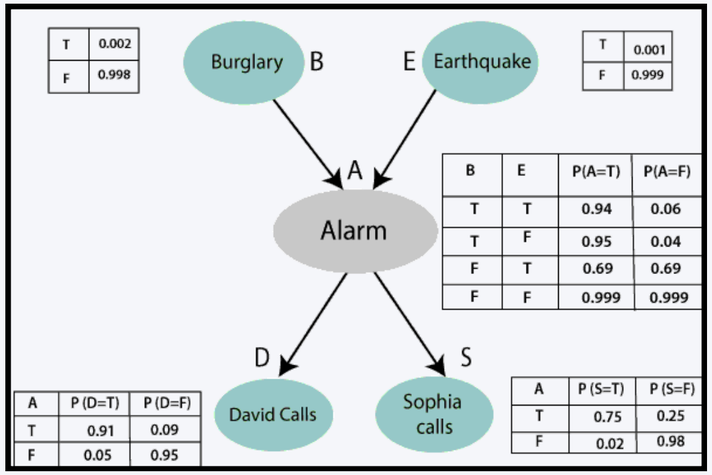
EXAMPLES OF KR LANGUAGES

- Logic-Based Systems:
  - Propositional Logic
  - First-order Predicate Calculus
- Probabilistic Models:
  - Bayesian Belief Networks
- Graph-Based Models:
  - Semantic Networks
- Other Methods:
  - Natural Language Processing (NLP)

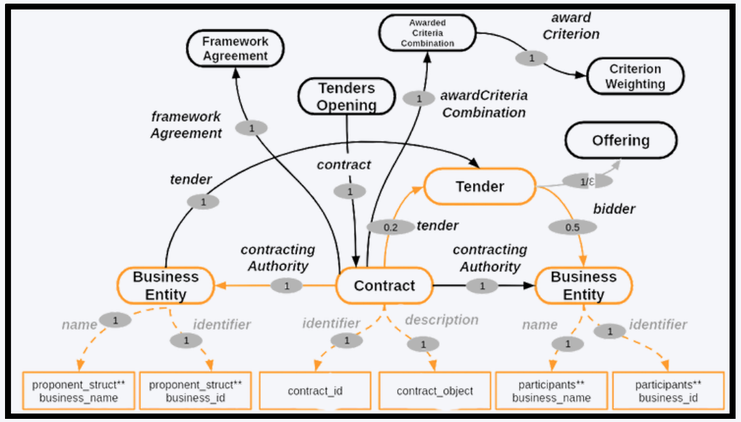
Note: No single KR system works for all scenarios. Complex AI systems often combine multiple representations.



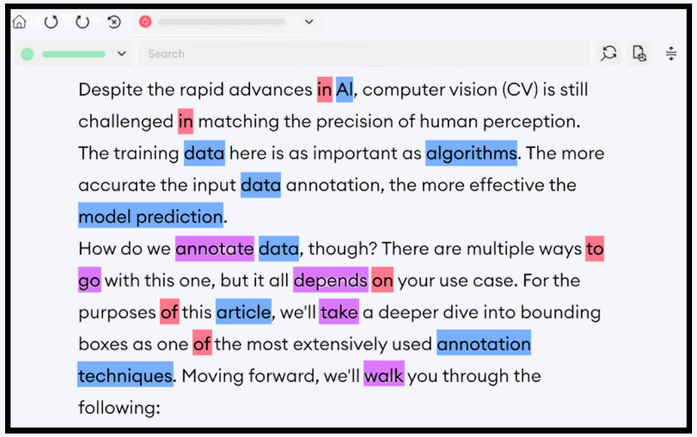
LOGIC-BASED SYSTEMS



BAYESIAN BELIEF NETWORKS



SEMANTIC NETWORK | GRAPH BASED



NLP

Poole & Mackworth, 2010 (http://artint.info/slides/), and Russell & Norvig, 2005 (http://aima.cs.berkeley.edu/)

KEY ASPECTS OF A KR LANGUAGE

- **Syntax:**
  - Defines valid configurations of language components.
  - Example: 2 + 3 ≡ 3 + 2 (Different syntax, same meaning).

- **Semantics:**
  - Defines the facts or meanings referred to by sentences.
  - Example: Division in Python 2 (3/2) vs. Python 3 (3/2) (Same syntax, different semantics).

- **Historical Context**
- Logic:
  - One of the oldest KR languages in AI.

  - Foundation for systems like:
    - Rule-based expert systems.
    - Prolog programming language.

Limitations of Search Algorithms

- Generate and evaluate successors but lack an understanding of the domain's context.

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KNOWLEDGE REPRESENTATION:
FIRST-ORDER LOGIC (FOL)

Why FOL?

- **FOL introduces objects, properties, and relations for complex reasoning.**

Key Features of FOL:

- **Objects: Entities (e.g., people, numbers, cars).**
- **Relations: Describe interactions (e.g., IsRed(x), ParentOf(x, y)).**
- **Functions: Map objects to other objects (e.g., FatherOf(x)).**

Poole & Mackworth, 2010 (http://artint.info/slides/), and Russell & Norvig, 2005 (http://aima.cs.berkeley.edu/)

FIRST-ORDER LOGIC (FOL)

SYNTAX OF FOL

- **Basic Components:**

  a. **Constants: Specific objects (e.g., John, PSAU).**
  b. **Variables: General placeholders (e.g., x, y).**
  c. **Functions: Map objects to other objects (e.g., FatherOf(John)).**
  d. **Predicates: Return True/False for relations (e.g., Greater(x, y)).**
  e. **Logical Connectives: ∧, ∨, ¬, →, ↔.**
  f. **Quantifiers:**
     - **Universal (∀): "For all" (e.g., ∀x Smart(x)).**
     - **Existential (∃): "There exists" (e.g., ∃x Knows(x, Math)).**

- **FOL Translation**

Translating natural language to FOL:

- "Everybody loves Ali" → ∀x Loves(x, Ali).

- "Someone at Tuwaiq is smart" → ∃x (At(x, Tuwaiq) ∧ Smart(x)).

Poole & Mackworth, 2010 (http://artint.info/slides/), and Russell & Norvig, 2005 (http://aima.cs.berkeley.edu/)

FIRST-ORDER LOGIC (FOL)

FOL INFERENCE METHODS

- Universal Instantiation (UI):
  - Substitutes universally quantified variables with specific constants.
  - **Example: ∀x Parent(x)→Caring(x). Substitute {x = Sara}, yielding Parent(Sarah) → Caring(Sarah)**

- Existential Instantiation (EI):
  - Replaces existential variables with a new constant.
  - **Example: ∃x Crown(x) → Crown(C1), where C1 is a new constant.**

- Propositionalization:
  - Converts FOL into propositional logic by grounding sentences.

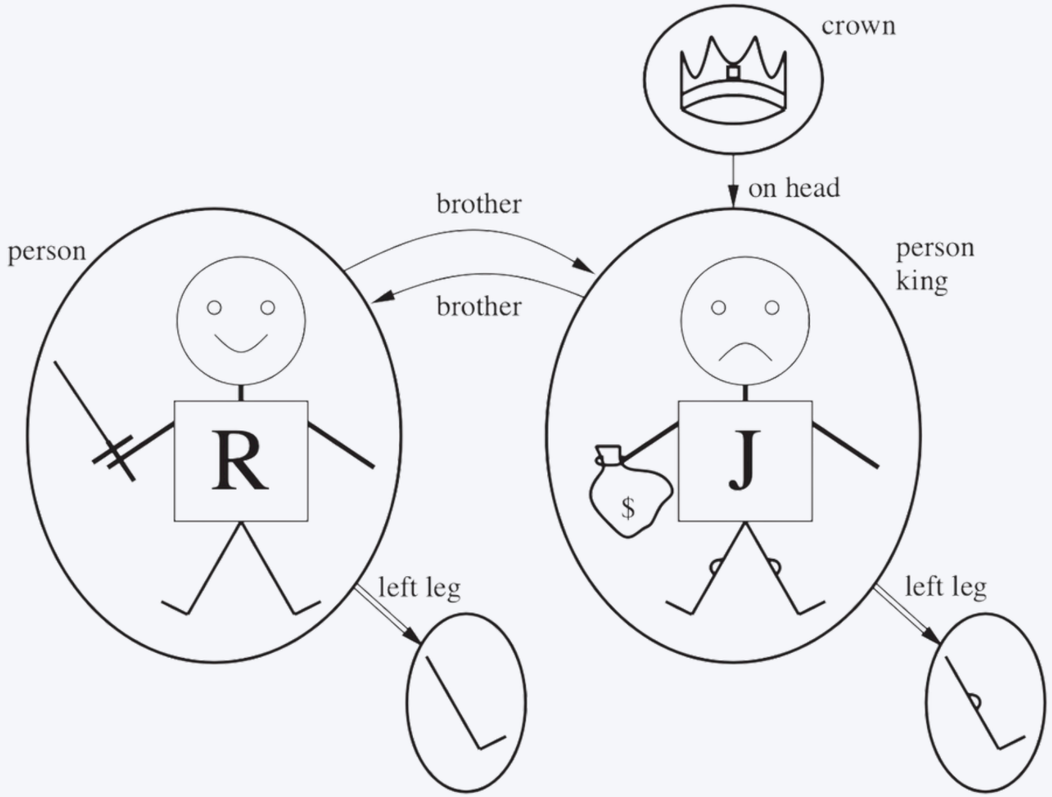
- Unification:
  - Finds substitutions to make two predicates identical.
  - **Example: UNIFY(Knows(John, x), Knows(John, Jane)) → {x/Jane}.**

- Forward and Backward Chaining:
  - Forward Chaining: Start with data, derive conclusions.
  - Backward Chaining: Start with a goal, trace back to data.

Poole & Mackworth, 2010 (http://artint.info/slides/), and Russell & Norvig, 2005 (http://aima.cs.berkeley.edu/)

FIRST-ORDER LOGIC (FOL)
FOL INFERENCE METHODS

- ¬Brother(LeftLeg(R), J)
- Brother(R, J) ∧ Brother(J, R)
- King(R) ∨ King(J)
- ¬ King(R) ⇒ King(J)



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AI Vs. Augmented Intelligence

WHAT IS ARTIFICIAL INTELLIGENCE?

Definition of AI: Artificial Intelligence (AI) refers to the simulation of human intelligence processes by computer systems.

Key Components:

- Utilizes algorithms and data.
- Enables machines to perform tasks typically requiring human intelligence.

Capabilities of AI:

- Learning.
- Reasoning.
- Problem-solving.
- Decision-making.

https://www.coursera.org/learn/introduction-to-ai/home/module/1

THE DIGITAL REVOLUTION

Impact of the Internet:

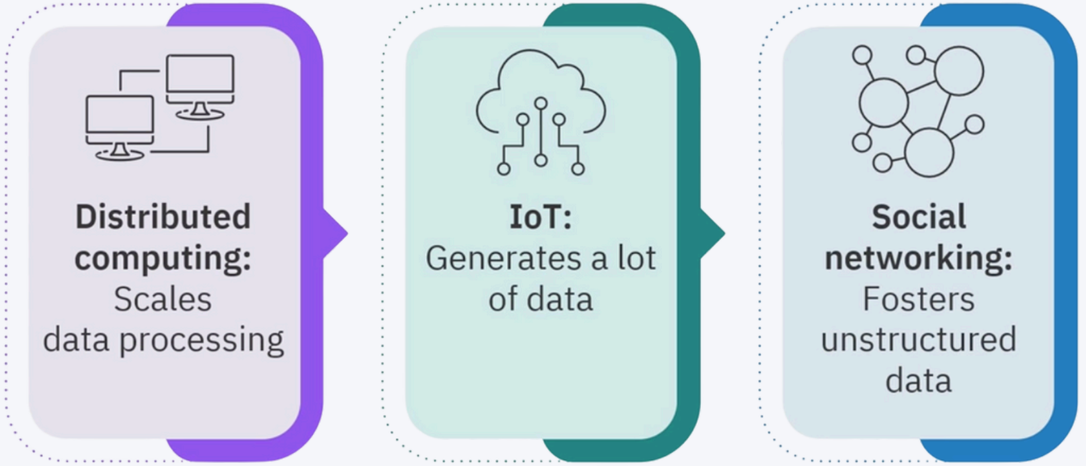
- Revolutionized connectivity.
- Provided faster access to a vast amount of information.

Role of Distributed Computing:

- Scales data processing.
- Enhances efficiency in handling large datasets.

Influence of IoT (Internet of Things):

- Proliferates connected devices.
- Generates massive amounts of data.



Effect of Social Networking:

- Encourages unstructured data creation by users.
- Collective Impact:
- Reshapes the digital landscape.
- Accelerates access to information and drives innovation.

https://www.coursera.org/learn/introduction-to-ai/home/module/1

WHAT AUGMENTED INTELLIGENCE DOES:

https://www.coursera.org/learn/introduction-to-ai/home/module/1

HOW DO WE DEFINE INNATE INTELLIGENCE?

Human beings have innate intelligence, which is defined as the intelligence that governs every activity in our body.

https://www.coursera.org/learn/introduction-to-ai/home/module/1

HOW AI LEARNS ?

AI learns from the intelligence and instructions we provide.

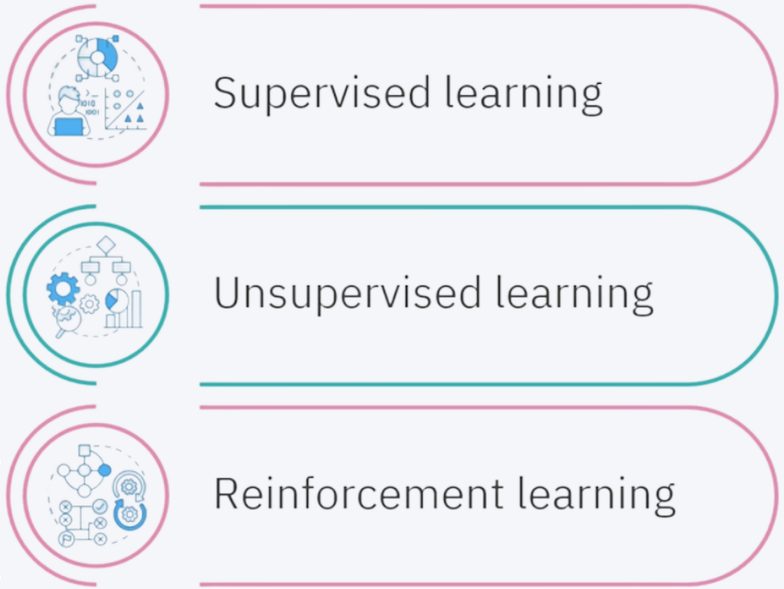
Machines analyze examples to create models that link inputs to desired outputs

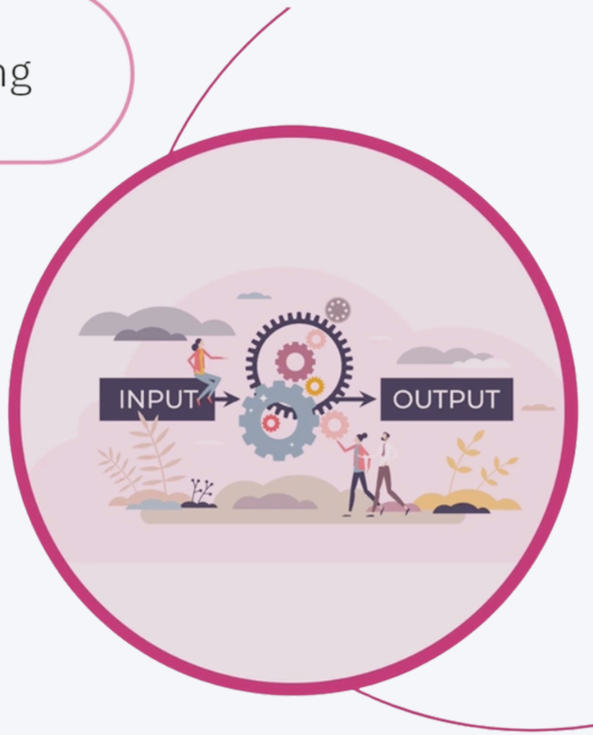
.

Learning Methods:

- Supervised Learning: Learning from labeled data where inputs and outputs are provided.
- Unsupervised Learning: Finding patterns in data without labeled outputs.
- Reinforcement Learning: Learning through trial and error to achieve a goal, guided by rewards and penalties.

Key Idea: Machines only learn based on the methods and information we supply.





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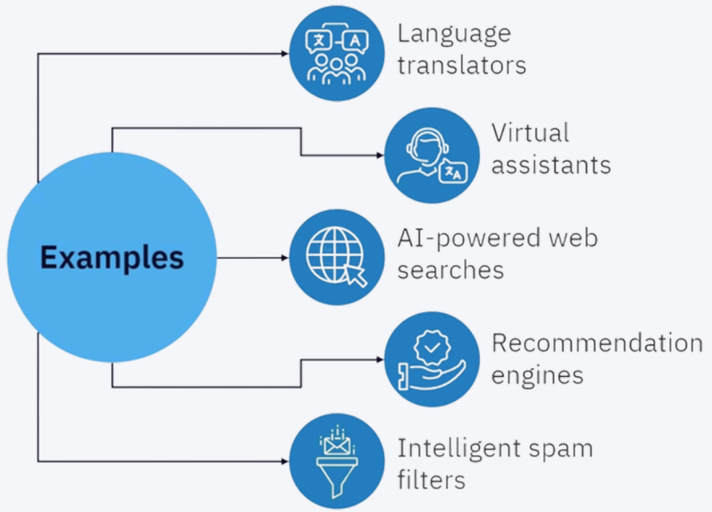
TYPES OF AI:

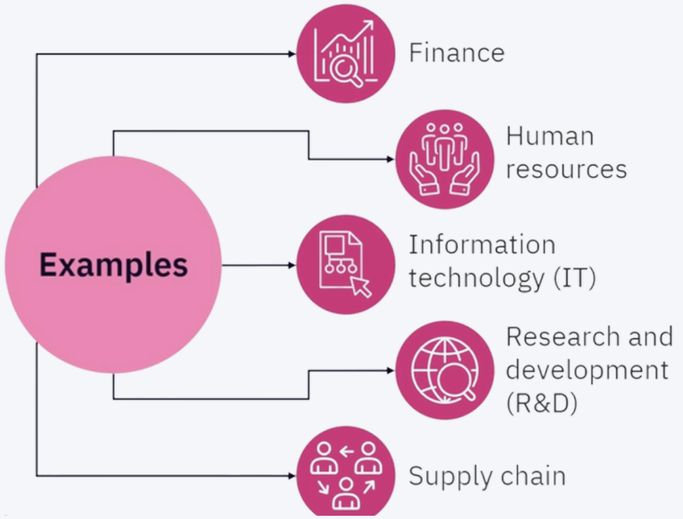
Weak AI

- An AI tailored for specific domains
- Decision-making based on programmed algorithms and training data



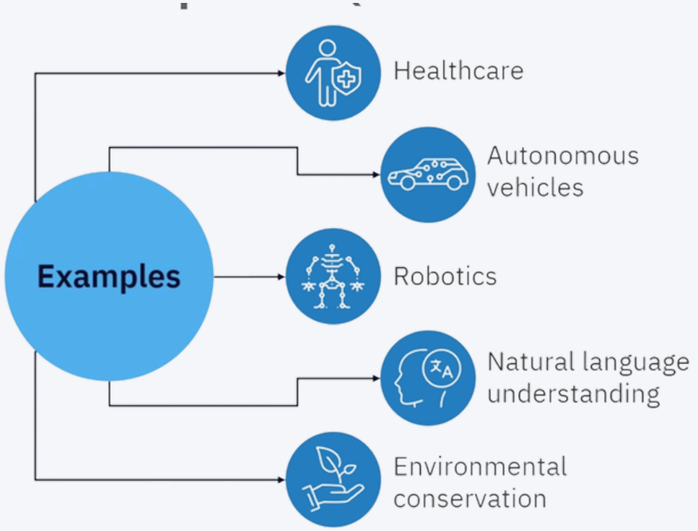
Strong AI

- An AI with diverse capabilities across unrelated tasks
- Acquires new skills to face new challenges
- Is an amalgamation of various AI strategies



Super AI

- AI with human-level consciousness
- Requires self-awareness



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THREE FORMS OF INTELLIGENCE IN EVERYDAY LIFE

Artificial Intelligence

Self-driving features manage tasks like lane keeping, speed control, and safe following distance.

Replaces human input entirely for specific tasks.

Human Intelligence

Operates the vehicle (steering, mirrors). Involves decision-making and manual control.

Augmented Intelligence

Driver-assist features like collision detection and blind spot warnings.

Enhances human abilities by working alongside us.

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THREE FORMS OF INTELLIGENCE IN EVERYDAY LIFE

Artificial Intelligence

- Performs tasks requiring human intelligence.
- Examples: Reasoning, problem-solving, natural communication.
- Fully replaces human involvement in tasks.

VS

Augmented Intelligence

- Combines human and machine efforts to improve performance.
- Examples: Voice navigation, collision avoidance, screen readers.
- Complements human abilities rather than replacing them.

https://www.coursera.org/learn/introduction-to-ai/home/module/1

WHICH ONE IS BETTER ..!

Strengths of Machines vs. Humans

Aspect	Machines	Humans
Data Processing	Ingest large amounts of data quickly and tirelessly.	Generalize concepts from limited data.
Accuracy	Reliable in repetitive tasks with no margin for error.	Prone to mistakes in repetitive tasks.
Creativity	Limited to programmed algorithms.	Generate new ideas and solve complex problems.
Emotional Intelligence	None.	Understand and respond to emotions.
Best Use	Repetitive, data-heavy tasks.	Customer service, caregiving, innovation.

By combining these strengths in augmented intelligence, humans and machines achieve optimal results, enabling us to thrive in a rapidly evolving world.

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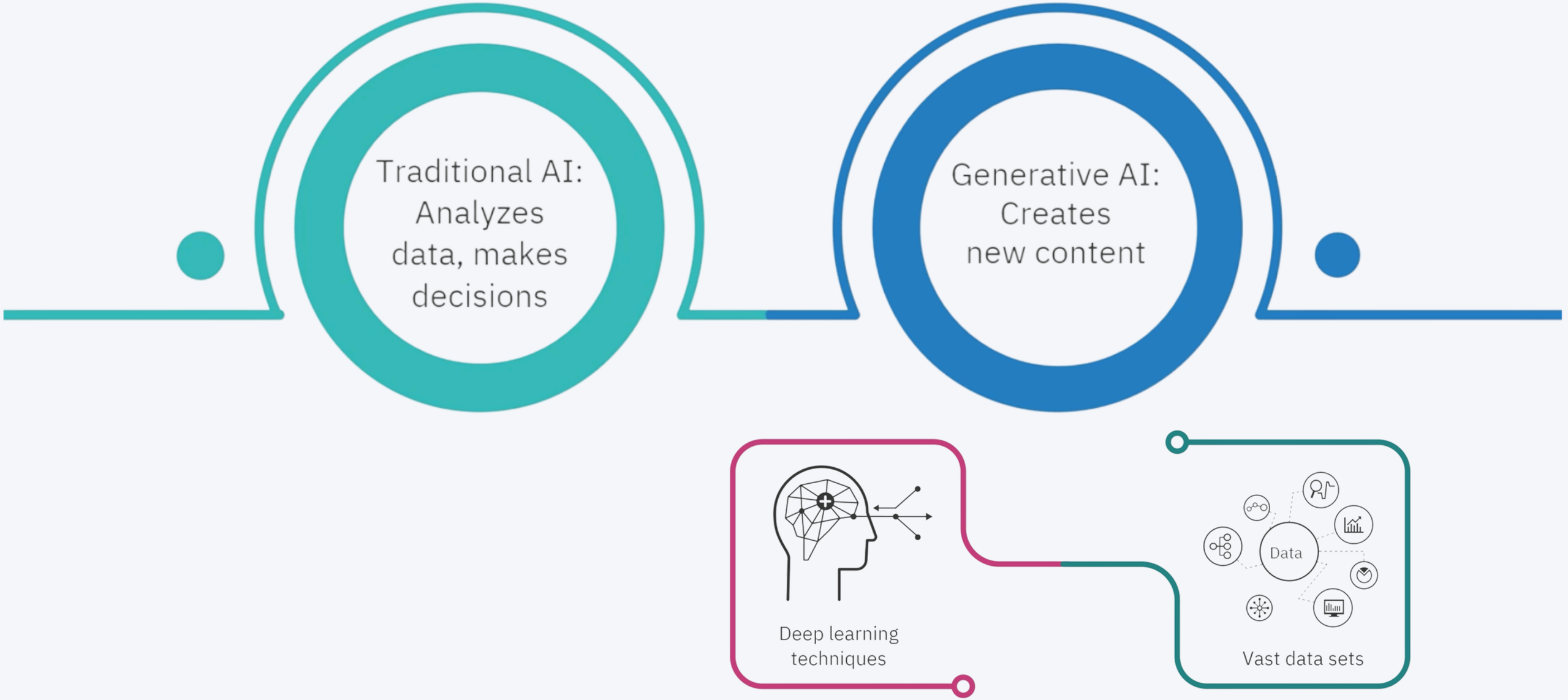
INTORUDCING GENERATIVE AI AND ITS APPLICATION



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TRADITIONAL AI: HOW IT WORKED

Key Components:

1. Repository: Stores historical data (tables, images, documents).
2. Analytics Platform: Tools like SPSS Modeler or Watson Studio to analyze data and build models.
3. Application Layer: Uses insights from models to take action (e.g., prevent customer churn).

Feedback Loop:

- Automates learning from successes and mistakes.
- Continuously improves model accuracy over time.

Example:

- Telco predicts customer churn, takes action to retain customers, and learns from results.

GENERATIVE AI: HOW IT WORKED

What's Different:

- **Massive Data:** Uses vast, global information, not limited to an organization's repository.
- **Large Language Models (LLMs):**
  - Built on diverse, expansive data.
  - General-purpose but powerful.

Challenges with LLMs:

- Lack specific organizational context.

Solution:

- **Prompting & Tuning:** Fine-tune general models for specific business needs (e.g., telco customer churn).

https://www.coursera.org/learn/introduction-to-ai/home/module/1

KEY DIFFERENCES: TRADITIONAL AI VS. GENERATIVE AI

Aspect	Traditional AI	Generative AI
Data Source	Organization-specific repository.	Global, diverse datasets ("data from earth").
Model Type	Predictive models tailored to specific tasks.	Large language models with broad knowledge.
Customization	Requires in-house analytics and feedback loops.	Fine-tuned using prompting and tuning layers.
Scalability	Limited by organizational data.	Handles massive quantities of data.

Generative AI reshapes the AI landscape by leveraging expansive data and powerful models, enabling businesses to achieve more with tailored solutions.

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Artificial Intelligence
Are we there yet ?

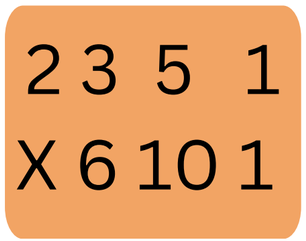
ARTIFICIAL INTELLIGENCE | ARE WE THERE YET ?

“One definition of AI is basically the simulation of intelligent behavior in computers.”

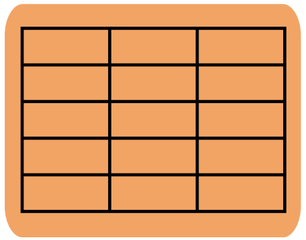
Artificial Intelligence.

“AGI describes an AI system equivalent to a human, as diverse as a human, and can do anything a human can do at least as well or better.”

Artificial General Intelligence.
(aspirational, not achieved).

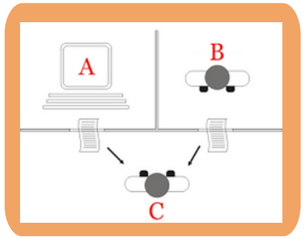


“If I tell you the answer to this math equation in my head, is that intelligence?”



“Knowing all the elements in the periodic table, their atomic numbers—is that intelligence?”

Chess grandmasters invest years in learning patterns, moves, and strategies. Is that intelligence?”



A computer passes the Turing test if a human cannot distinguish it from another person during communication, Is that intelligence?”

“I talk with ChatGPT daily, and sometimes I could be convinced it’s a real person, Is that intelligence?”

“I have a self-driving car that brings me to work. It’s basically a computer that takes me places. Is that intelligence?”

“I’m not a great photographer, but I use AI prompting to generate professional pictures.”. Is that intelligence?”

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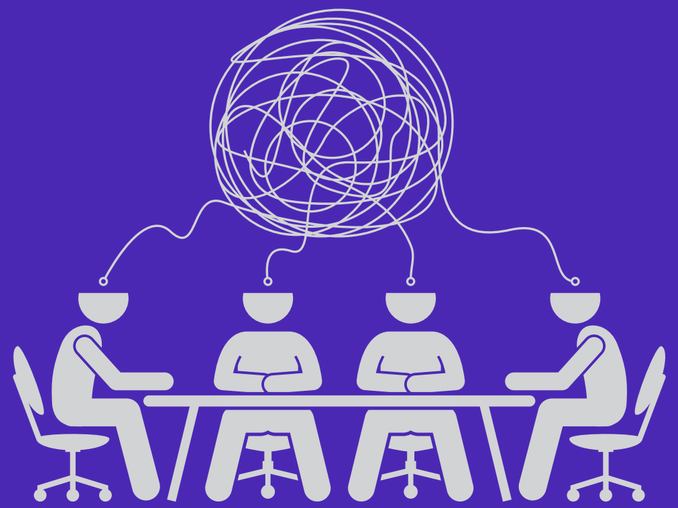
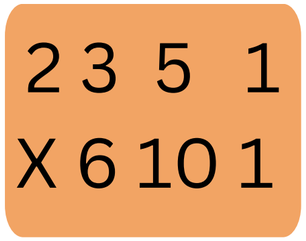
DISCUSSION QUESTIONS

- Do you think tasks like math calculation or memorization qualify as intelligence? Why or why not?
- How would you define intelligence in humans versus machines?
- How close do you think we are to achieving AGI?
- What would be the potential benefits and risks of AGI?



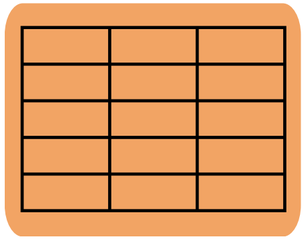
ARTIFICIAL INTELLIGENCE | ARE WE THERE YET ?

basic computational ability



“If I tell you the answer to this math equation in my head, is that intelligence?”

database lookup

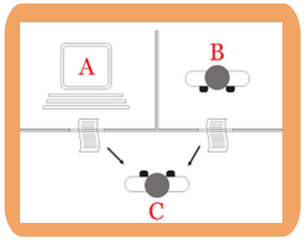


“Knowing all the elements in the periodic table, their atomic numbers—is that intelligence?”

Specialized narrow AI

Chess grandmasters invest years in learning patterns, moves, and strategies. Is that intelligence?”

goal yet to be fully achieved



A computer passes the Turing test if a human cannot distinguish it from another person during communication, Is that intelligence?”

conversational AI

“I talk with ChatGPT daily, and sometimes I could be convinced it’s a real person, Is that intelligence?”

Applied AI

“I have a self-driving car that brings me to work. It’s basically a computer that takes me places. Is that intelligence?”

Generative AI

“I’m not a great photographer, but I use AI prompting to generate professional pictures.”. Is that intelligence?”

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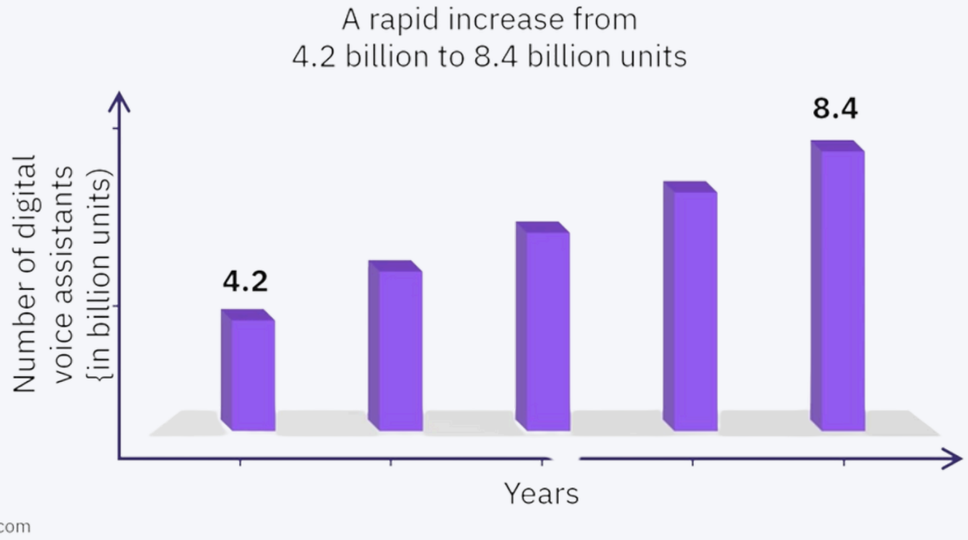
AI IN DAILY LIFE

- **Statista: Digital voice assistants increased from 4.2B to 8.4B in 5 years.**

AI enhances:

- Personalized experiences.
- Task automation and efficiency.
- Accessibility and convenience.
- Safety and security.
- Navigation and healthcare.



Efficiency and Convenience:

- Automating Daily Tasks
- Key Points:
  - Virtual Assistants: Siri, Alexa, Google Assistant.
  - Manage reminders, answer questions, control devices.
- Smart Homes:
  - AI automates temperature, lighting, and security for convenience and energy efficiency.

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AI IN DAILY LIFE

Personalized Experiences:

- Tailored to Your Preferences

Key Points:

  - Streaming Platforms (Netflix, Spotify): Recommend movies, music, etc.
  - Social Media (Facebook, Instagram): Personalized content feed.
  - E-Commerce (Amazon, eBay): Suggest products based on browsing history.

Enhanced Security:

- Boosting Safety with AI

Key Points:

  - Cybersecurity: Encryption, access control, risk assessment.
  - Fraud Detection: Identifies unusual activities in transactions.
  - Biometric Authentication: Facial recognition, fingerprint, voice ID.
  - Video Analytics: Improves surveillance and fraud prevention.

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WHAT ARE AI CHATBOTS AND SMART ASSISTANTS?

- **Key Points:**
  - AI-driven programs that understand queries, provide information, and perform tasks.
  - Use Natural Language Processing (NLP) to simulate human-like conversations.

- **Evolution**:
    - From rule-based systems to AI-powered assistants.
    - Generative AI chatbots: Context-based conversations and personalized recommendations.

Examples of Chatbots and Assistants

- **Key Points:**
  - Chatbot Platforms: IBM Watson Assistant, Chatfuel, wit.ai.
  - Smart Assistants: Siri, Google Assistant, Alexa, Cortana.
  - Generative AI Chatbots: ChatGPT, Google Gemini, LLaMA

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