Artificial Intelligence

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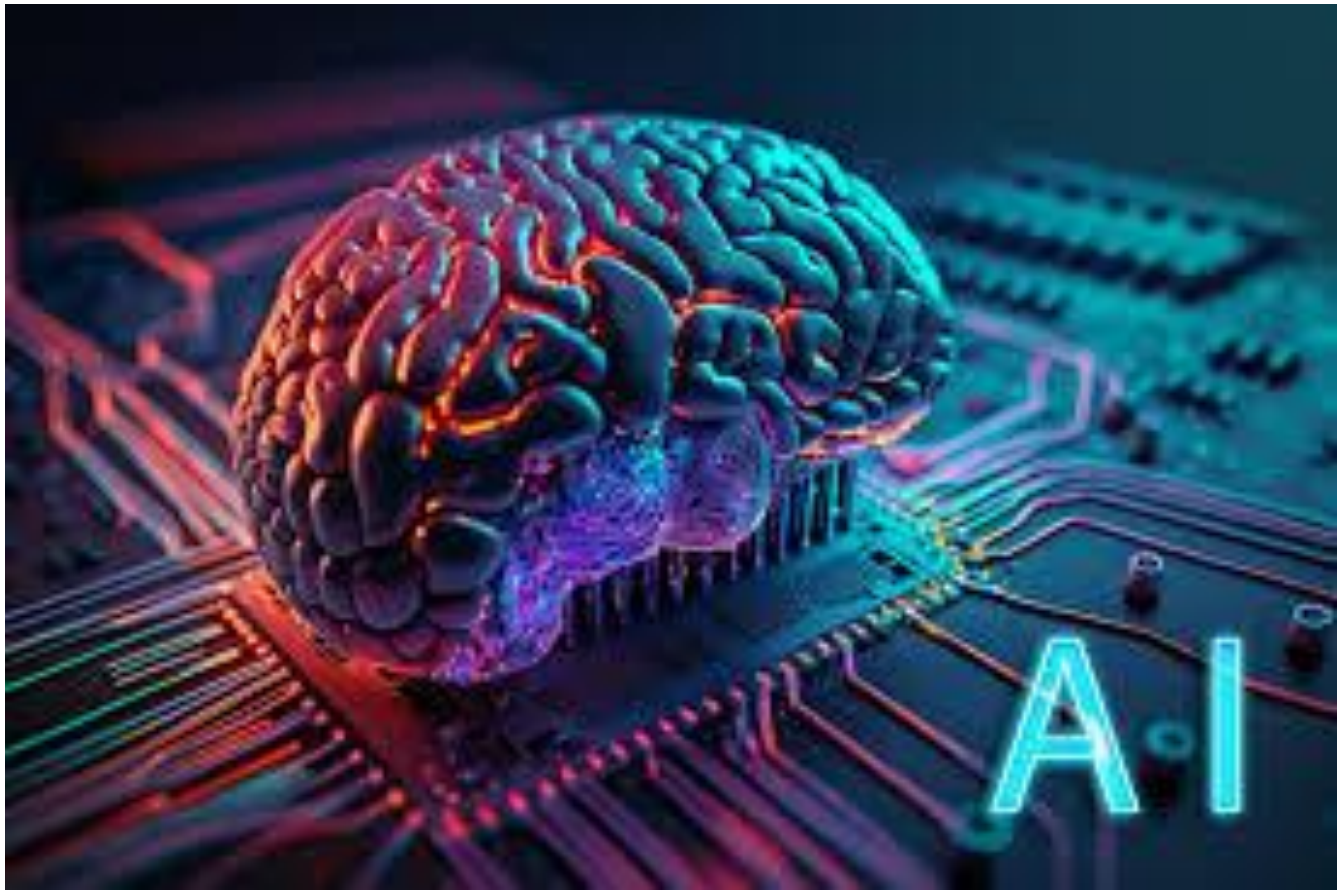
Introduction

Overview

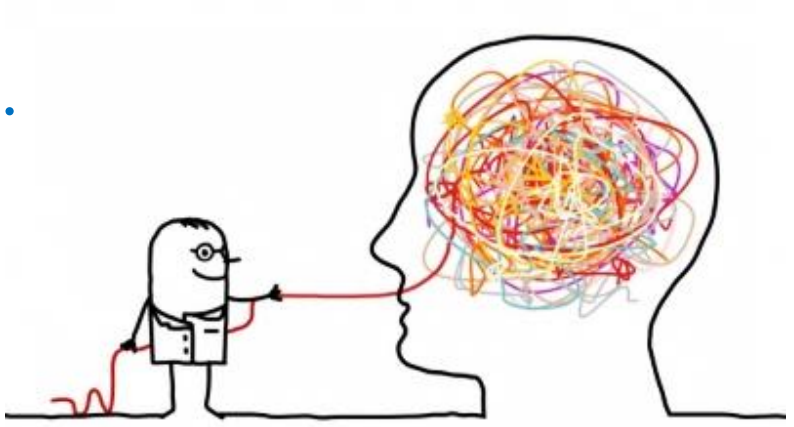
- Human Intelligence
- What is Artificial Intelligence?
- Four Schools of thought
- Turing Test
- John Searle’s argument
- History of AI
- Success Stories
- Can Computers beat Humans?
- Influential areas for AI
- AI Applications



What is Intelligence?

Intelligence is the ability to acquire and apply knowledge and skills. It encompasses a wide range of mental capabilities, including learning from experience, understanding complex ideas, adapting to new situations, reasoning, problem-solving, and using knowledge to manipulate one's environment or think abstractly.

- Intelligence:
  - "the capacity to learn and solve problems"
  - the ability to acquire and apply knowledge and skills.
  - in particular,
    - *the ability to solve novel problems*
    - *the ability to act rationally*
    - *the ability to act like humans*



Key Characteristics of Intelligence

- **Learning** – The ability to gain knowledge and improve behavior from past experiences.
- **Reasoning** – The capability to solve problems and make decisions logically.
- **Understanding** – Grasping the meaning of things, concepts, or situations.
- **Adaptation** – Adjusting behavior to fit new environments or challenges.
- **Problem-Solving** – Finding solutions to unfamiliar or complex issues.
- **Creativity** – Generating new ideas or approaches.
- **Memory** – Storing and recalling information effectively.
- **Perception** – Interpreting sensory data to interact with the environment

Scientific Definitions of Intelligence

- **Psychology (APA)**: *"The ability to derive information, learn from experience, adapt to the environment, understand, and correctly use thought and reason."*
- **Howard Gardner's Theory of Multiple Intelligences**: Intelligence is not a single ability but a collection of distinct capacities (e.g., linguistic, spatial, logical-mathematical, musical, interpersonal).
- **AI Perspective**: *"The computational part of the ability to achieve goals in the world."* – **John McCarthy**, one of the fathers of AI.

Natural (human) intelligence

- **Learning** from experience
- **Solving problems**
- **Reasoning** and logical thinking
- **Adapting** to new situations
- **Communicating** and understanding language

Can replicate or simulate these abilities in machines.

What is Artificial Intelligence?

Artificial Intelligence (AI) is the branch of computer science that focuses on creating machines and software capable of performing tasks that typically require human intelligence. These tasks include learning, reasoning, problem-solving, understanding language, and perceiving the environment. (ChatGPT)

- Concerned with building smart machines capable of performing tasks that typically require human intelligence
- Build and understand intelligent entities or agents
- Studies and develops intelligent machines and software

Definitions

Artificial intelligence (AI), sometimes called machine intelligence, is intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans and other animals **(Wikipedia)**

> The exciting new effort to make computers think …machines with minds, in the full literal sense. ***(Haugeland, 1985)***

The study of how to make computers do things at which, at the moment, people are better. ***(Rich & Knight, 1991)***

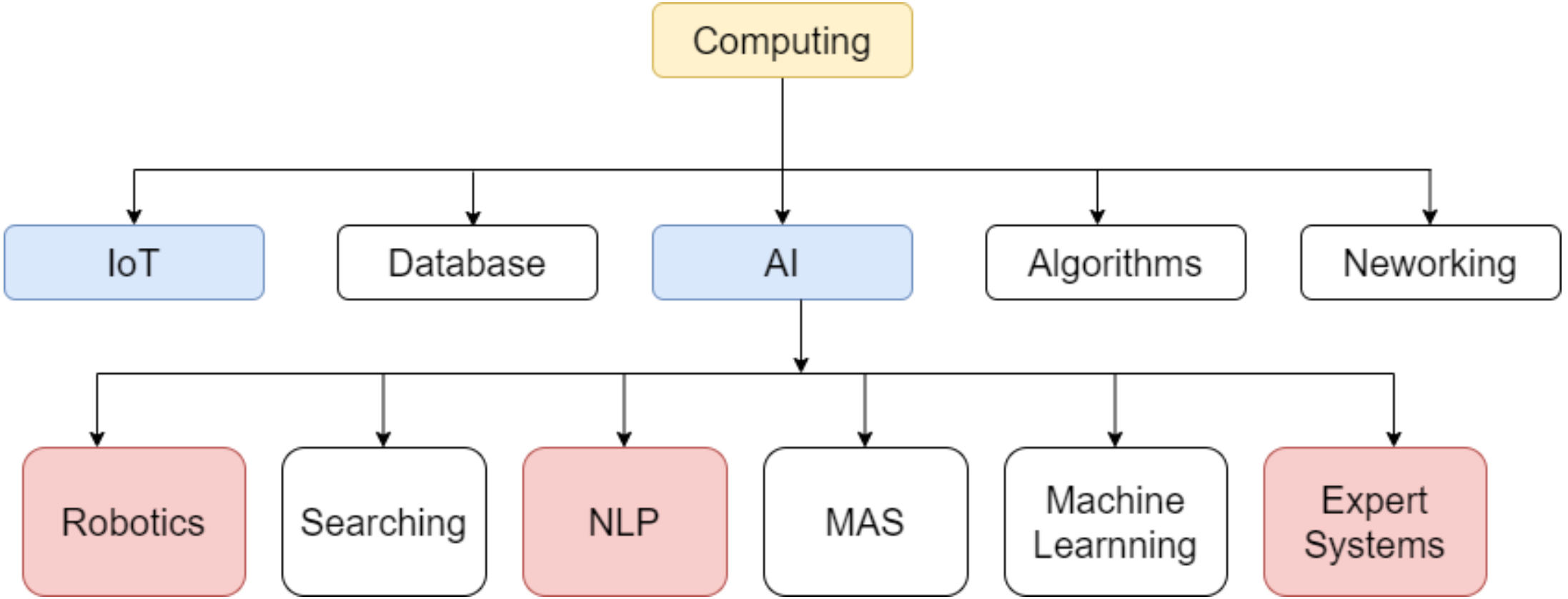
Definition of AI

- John McCarthy (Father of AI):
  "The science and engineering of making intelligent machines, especially intelligent computer programs."
- Elaine Rich:
  "AI is the study of how to make computers do things which, at the moment, people do better."
- Russell and Norvig (AI Textbook):
  "The study of agents that receive percepts from the environment and perform actions."

Goals of Artificial Intelligence

- **Scientific goal**: understand the mechanism behind human intelligence.
- **Engineering goal**: develop concepts and tools for building intelligent agents capable of solving real world problems. Examples:
  - **Knowledge-based systems**:
  - **Natural language understanding systems**.
  - **Intelligent robots.**
  - **Speech and vision recognition systems.**
  - **Game playing (IBM's Deep Blue)**

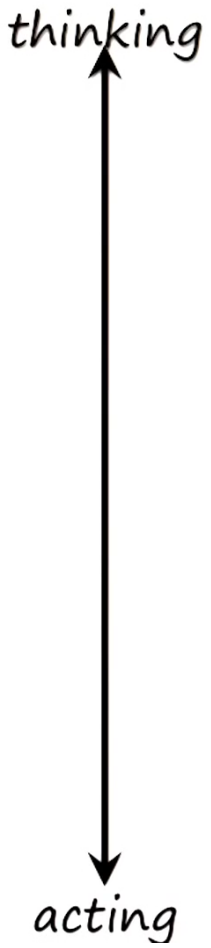
AI Taxonomy?


Computing
IoT
Database
AI
Algorithms
Neworking
Robotics
Searching
NLP
MAS
Machine Learnning
Expert Systems

Four Schools of Thought

- The **Four Schools of Thought**, as introduced by Russell and Norvig in their seminal AI textbook, provide a framework that classifies AI based on two dimensions:
- **Thinking vs. Acting**
- **Humanly vs. Rationally**
- These lead to four distinct approaches:

Artificial Intelligence



Thinking Humanly – The Cognitive Modeling Approach

- Goal: Build systems that think like humans.
- Inspired by: Psychology and cognitive science.
- Focus: Replicating the actual thought processes of the human mind.
- Techniques: Cognitive modeling, brain simulation, neural networks.
- Tools: Think-aloud protocols, brain imaging (fMRI), human behavioral studies.
- Example:
  An AI model that mimics how humans solve math problems by simulating human memory, attention span, and decision-making steps.

Acting Humanly – The Turing Test Approach

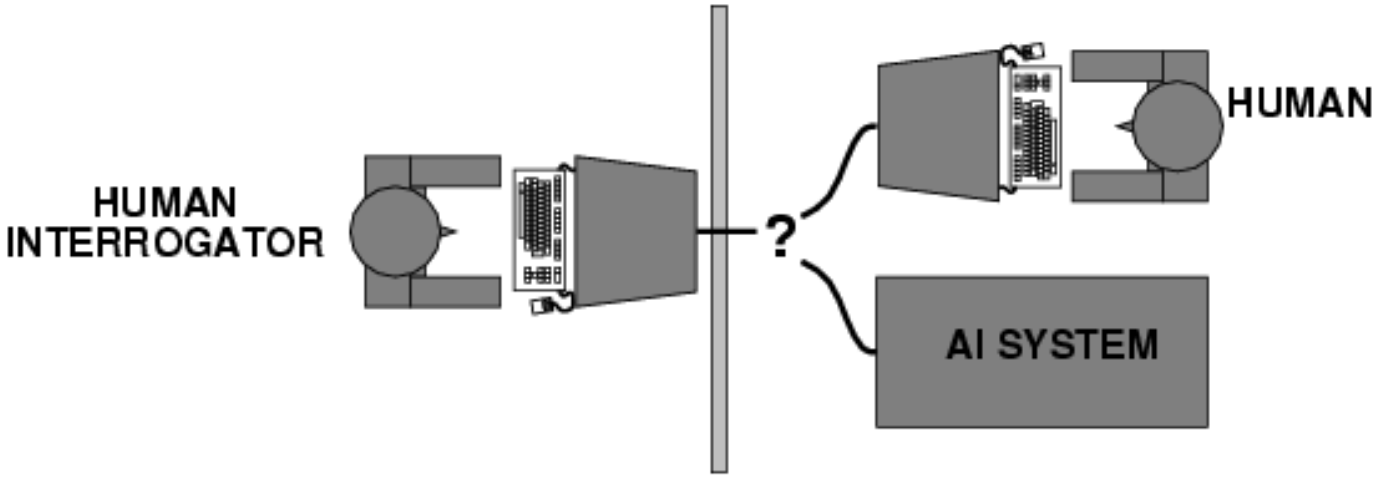
- **Goal**: Make machines behave like humans.
- **Inspired by**: Alan Turing's Imitation Game.
- **Test**: If a machine can convincingly imitate human responses, it passes the test.
- **Focus**: Natural language processing, perception, and social behavior.
- **Techniques**: Chatbots, speech recognition, robotics.
- **Example**:
  A chatbot that holds conversations indistinguishable from a human in real-time (e.g., ChatGPT in a customer support role).

Thinking Rationally – The Laws of Thought Approach

- **Goal**: Make machines reason logically.
- **Inspired by**: Formal logic (Aristotle's syllogisms, propositional logic).
- **Focus**: Deductive reasoning, mathematical proofs, logical inference.
- **Techniques**: Logic programming (e.g., Prolog), rule-based systems.
- **Example**:
  An expert system that deduces a medical diagnosis using logic rules like "IF symptoms A and B, THEN disease X."

Acting humanly: Turing test

- Turing (1950) "Computing machinery and intelligence“
- "Can machines think?" → "Can machines behave intelligently?“
- Operational test for intelligent behavior: the Imitation Game
- Suggests major components required for AI:
  - knowledge representation
  - reasoning,
  - language/image understanding,
  - learning



Turing test

John Searle’s argument

Some areas of AI

- Expert systems
- Machine Learnning
- Fuzzy Logic
- Genetic Algorithms
- Case-base reasoning
- Natural Language Processing
- Computer Vision
- Robotics
- Agents and Multi agent systems

History of AI

- 1943: early beginnings
  - McCulloch & Pitts: Boolean circuit model of brain
- 1950: Turing
  - Turing's "Computing Machinery and Intelligence“
- 1956: birth of AI
  - Dartmouth meeting: "Artificial Intelligence“ name adopted
- 1950s: initial promise
  - Early AI programs, including
  - Samuel's checkers program
  - Newell & Simon's Logic Theorist
- 1955-65: “great enthusiasm”
  - Newell and Simon: GPS, general problem solver
  - Gelertner: Geometry Theorem Prover
  - McCarthy: invention of LISP

History of AI

- 1966—73: Reality dawns
  - Realization that many AI problems are intractable
  - Limitations of existing neural network methods identified
    - Neural network research almost disappears

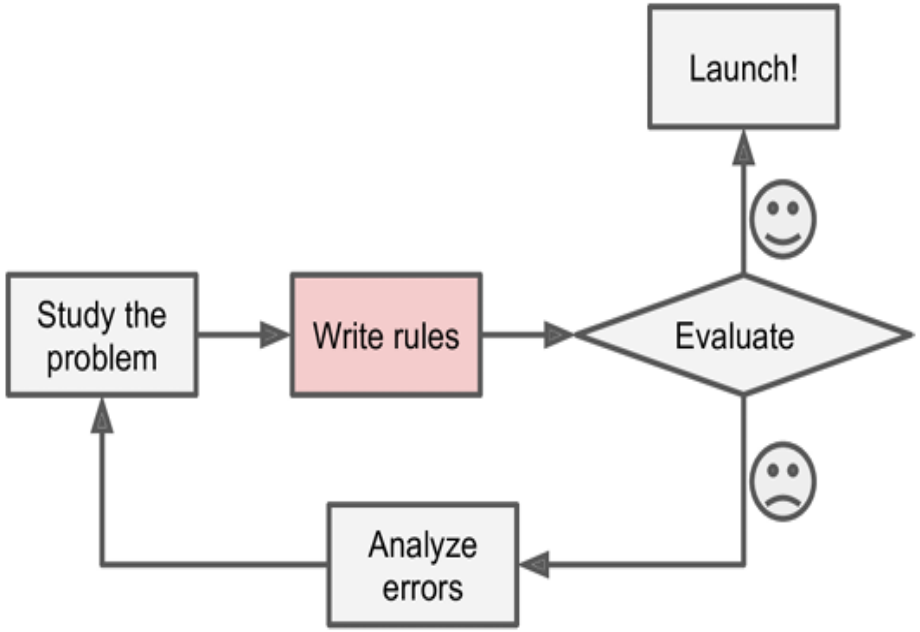
- 1969—85: Adding domain knowledge
  - Development of knowledge-based systems
  - Success of rule-based expert systems,
    - E.g., DENDRAL, MYCIN
    - But were brittle and did not scale well in practice

- 1986-- Rise of machine learning
  - Neural networks return to popularity
  - Major advances in machine learning algorithms and applications

- 1990-- Role of uncertainty
  - Bayesian networks as a knowledge representation framework

- 1995-- AI as Science
  - Integration of learning, reasoning, knowledge representation
  - AI methods used in vision, language, data mining, etc

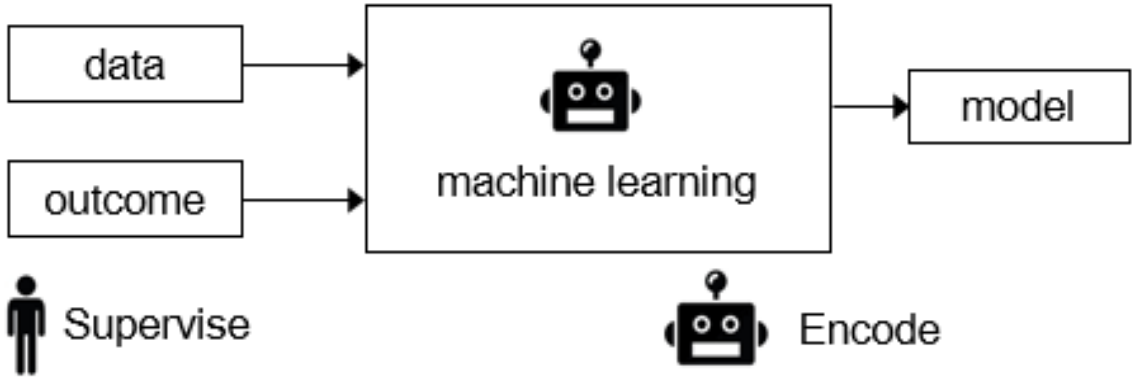
The Traditional Approach




```python
# Function to convert Celsius to Fahrenheit
def celsius_to_fahrenheit(celsius):
    fahrenheit = (celsius * 9/5) + 32
    return fahrenheit

# Input from user
celsius = float(input("Enter temperature in Celsius: "))
# Conversion
fahrenheit = celsius_to_fahrenheit(celsius)
# Output result
print(f"{celsius}°C is equal to {fahrenheit:.2f}°F")
```

AI (Machine Learning Approach)



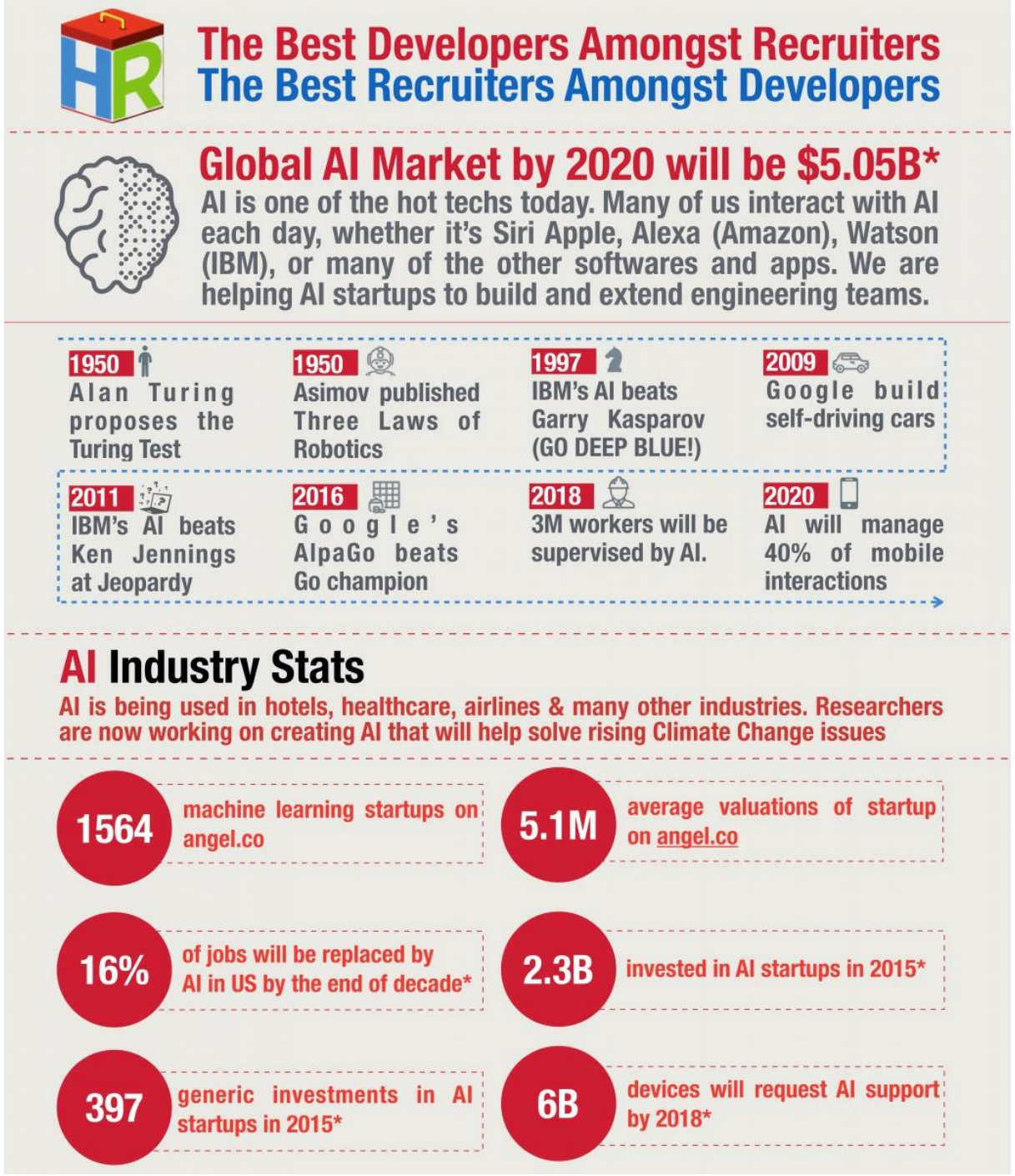

```
import numpy as np
from sklearn.linear_model import LinearRegression
import matplotlib.pyplot as plt

# Step 1: Create dataset (Celsius to Fahrenheit)
# y = (x * 9/5) + 32
celsius = np.array([[-40], [-30], [-20], [-10], [0], [10], [20], [30], [40], [50]])
fahrenheit = np.array([[-40], [-22], [-4], [14], [32], [50], [68], [86], [104], [122]])
```

```
# Step 2: Create and train the model
model = LinearRegression()
model.fit(celsius, fahrenheit)

# Step 3: Test the model
test_celsius = np.array([[100], [37], [25]])
predicted_fahrenheit = model.predict(test_celsius)

# Output results
for c, f in zip(test_celsius, predicted_fahrenheit):
    print(f"Celsius: {c[0]}°C -> Fahrenheit (predicted): {f[0]:.2f}°F")
```


The Best Developers Amongst Recruiters
The Best Recruiters Amongst Developers
Global AI Market by 2020 will be $5.05B*
AI is one of the hot techs today. Many of us interact with AI each day, whether it's Siri Apple, Alexa (Amazon), Watson (IBM), or many of the other softwares and apps. We are helping AI startups to build and extend engineering teams.
1950 Alan Turing proposes the Turing Test
1950 Asimov published Three Laws of Robotics
1997 IBM's AI beats Garry Kasparov (GO DEEP BLUE!)
2009 Google build self-driving cars
2011 IBM's AI beats Ken Jennings at Jeopardy
2016 Google's AlpaGo beats Go champion
2018 3M workers will be supervised by AI.
2020 AI will manage 40% of mobile interactions
AI Industry Stats
AI is being used in hotels, healthcare, airlines & many other industries. Researchers are now working on creating AI that will help solve rising Climate Change issues
1564 machine learning startups on angel.co
5.1M average valuations of startup on angel.co
16% of jobs will be replaced by AI in US by the end of decade*
2.3B invested in AI startups in 2015*
397 generic investments in AI startups in 2015*
6B devices will request AI support by 2018*

Success Stories

- Deep Blue defeated the reigning world chess champion Garry Kasparov in 1997
- AI program proved a mathematical conjecture (Robbins conjecture) unsolved for decades
- During the 1991 Gulf War, US forces deployed an AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people
- NASA's on-board autonomous planning program controlled the scheduling of operations for a spacecraft
- Proverb solves crossword puzzles better than most humans
- Robot driving: DARPA grand challenge 2003-2007
- 2006: face recognition software available in consumer cameras

Modern classification of AI

Reactive Machines

- Characteristics: No memory or data storage; reacts to current inputs.
- Examples: IBM’s Deep Blue chess-playing computer.
- Limitation: Cannot learn or adapt.

Limited Memory

- Characteristics: Can use past experiences to make decisions.
- Examples: Self-driving cars, recommendation systems.
- Key Feature: Uses historical data for predictions and learning.

Modern classification of AI

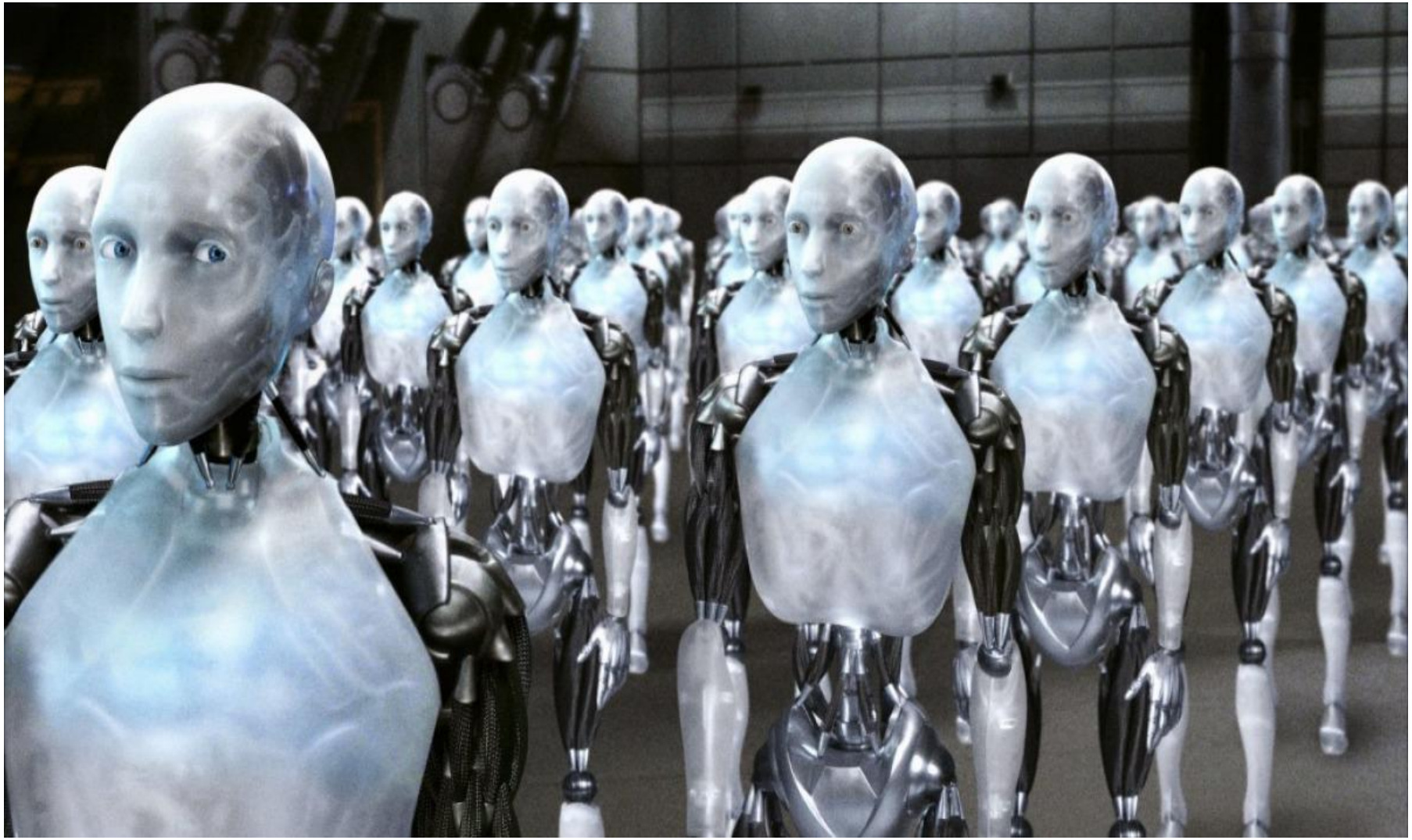
Theory of Mind (in progress)

- Definition: AI that understands emotions, beliefs, and intentions of others.
- Examples: Still under research.
- Goal: Social intelligence and emotional interaction.

Self-aware AI

- Definition: AI with consciousness, self-awareness, and sentience.
- Examples: Purely theoretical.
- Implication: Raises complex ethical and philosophical questions.

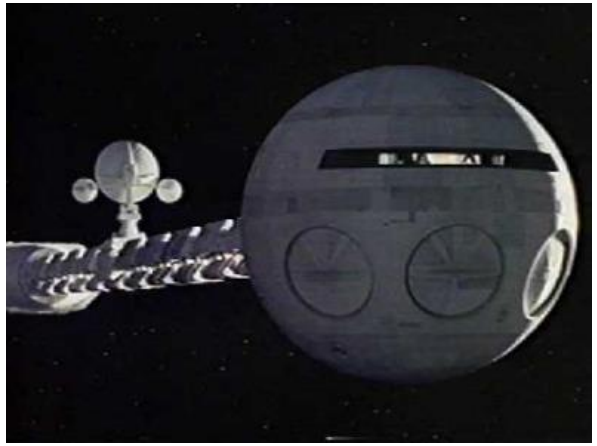
Dreams: iRobot,



HAL: from the movie 2001

- 2001: A Space Odyssey
  - classic science fiction movie from 1969

- Part of the story centers around an intelligent computer called HAL
- HAL is the “brains” of an intelligent spaceship
- in the movie, HAL can
  - speak easily with the crew
  - see and understand the emotions of the crew
  - navigate the ship automatically
  - diagnose on-board problems
  - make life-and-death decisions
  - display emotions



Consider what might be involved in building a computer like Hal….

- What are the components that might be useful?
  - Fast hardware?
  - Chess-playing at grandmaster level?
  - Speech interaction?
    - speech synthesis
    - speech recognition
    - speech understanding
  - Image recognition and understanding ?
  - Learning?
  - Planning and decision-making?

Can we build hardware as complex as the brain?

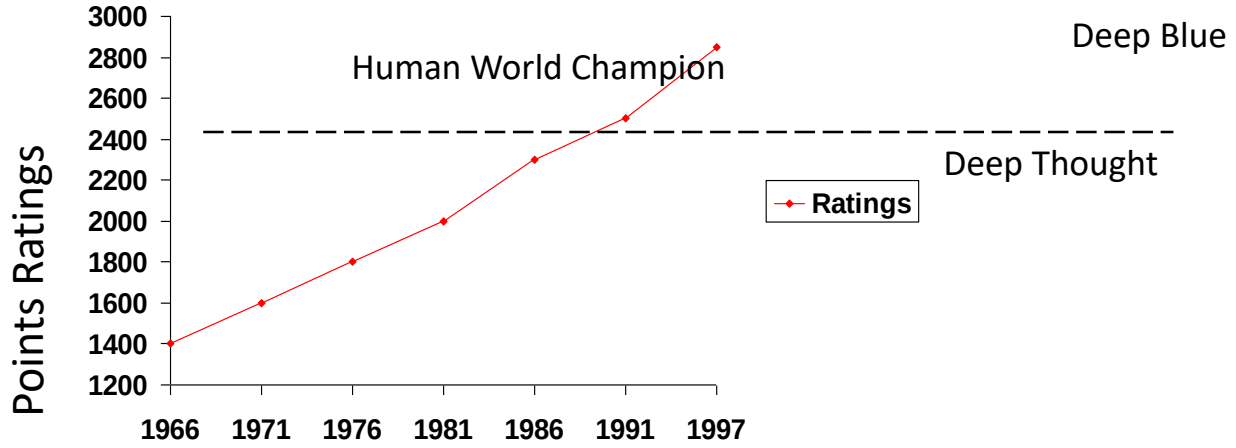
- How complicated is our brain?
  - A neuron, or nerve cell, is the basic information processing unit
  - estimated to be on the order of 10^{12} neurons in a human brain
  - many more synapses (10^{14}) connecting these neurons
  - cycle time: 10^{-3} seconds (1 millisecond)

- How complex can we make computers?
  - 10^8 or more transistors per CPU
  - supercomputer: hundreds of CPUs, 10^{12} bits of RAM
  - cycle times: order of 10^{-9} seconds

- Conclusion
  - **YES**: in the near future we can have computers with as many basic processing elements as our brain, but with
    - far fewer interconnections (wires or synapses) than the brain
    - much faster updates than the brain
  - But building hardware is very different from making a computer behave like a brain!

Can Computers beat Humans at Chess?

- Chess Playing is a classic AI problem
  - well-defined problem
  - very complex: difficult for humans to play well



- Conclusion:
  - YES: today's computers can beat even the best human

Can Computers Talk?

- This is known as “speech synthesis”
  - translate text to phonetic form
    - e.g., “fictitious” -> fik-tish-es
  - use pronunciation rules to map phonemes to actual sound
    - e.g., “tish” -> sequence of basic audio sounds

- Difficulties
  - sounds made by this “lookup” approach sound unnatural
  - sounds are not independent
    - e.g., “act” and “action”
    - modern systems (e.g., at AT&T) can handle this pretty well
  - a harder problem is emphasis, emotion, etc
    - humans understand what they are saying
    - machines don’t: so they sound unnatural

- Conclusion:
  - NO, for complete sentences
  - YES, for individual words

A.L.I.C.E

- The A.L.I.C.E. AI Foundation promotes the adoption of the A.L.I.C.E.
- Free open source software for
  - chatrobots,
  - chat robots
  - Chatterbots
  - Chatterboxes
- **http://alice**.pandorabots.com
- chatGPT

Can Computers Recognize Speech?

- Speech Recognition:
  - mapping sounds from a microphone into a list of words
  - classic problem in AI, very difficult
    - “Lets talk about how to wreck a nice beach”
    - (I really said “_____”)
- Recognizing single words from a small vocabulary
  - systems can do this with high accuracy (order of 99%)
  - e.g., directory inquiries
    - limited vocabulary (area codes, city names)
    - computer tries to recognize you first, if unsuccessful hands you over to a human operator
    - saves millions of dollars a year for the phone companies

Can Computers Understand speech?

- Understanding is different to recognition:
  - "Time flies like an arrow"
    - assume the computer can recognize all the words
    - how many different interpretations are there?
      - 1. time passes quickly like an arrow?
      - 2. command: time the flies the way an arrow times the flies
      - 3. command: only time those flies which are like an arrow
      - 4. "time-flies" are fond of arrows

Can Computers Understand speech?

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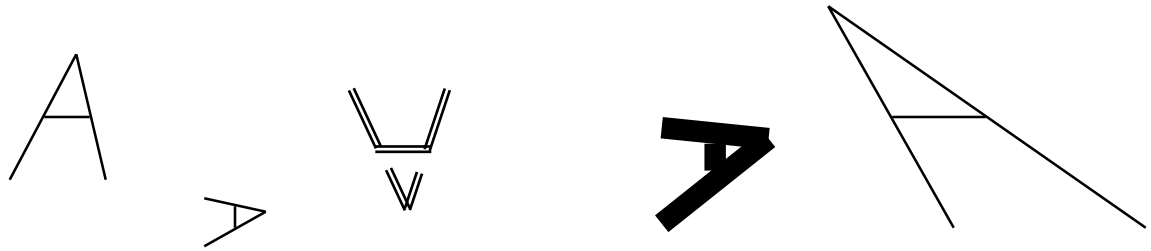
      - 3. command: only time those flies which are like an arrow
      - 4. "time-flies" are fond of arrows
    - only 1. makes any sense,
      - but how could a computer figure this out?
      - clearly humans use a lot of implicit commonsense knowledge in communication

- **Conclusion**: NO, much of what we say is beyond the capabilities of a computer to understand at present

Can Computers “see”?

- Recognition v. Understanding (like Speech)
  - Recognition and Understanding of Objects in a scene
    - look around this room
    - you can effortlessly recognize objects
    - human brain can map 2d visual image to 3d “map”
- Why is visual recognition a hard problem?



- Conclusion:
  - mostly NO: computers can only “see” certain types of objects under limited circumstances
  - YES for certain constrained problems (e.g., face recognition)

AI Applications: Machine Translation

- Language problems in international business
  - E.g., at a meeting of Japanese, Korean, Vietnamese and Swedish investors, no common language
  - Or: you are shipping your software manuals to 127 countries
  - Solution; hire translators to translate
  - Would be much cheaper if a machine could do this

- How hard is automated translation
  - Very difficult! e.g., English to Sinhala
  - Not only must the words be translated, but their meaning also!
  - Is this problem “AI-complete”?

AI vs. Traditional Programming

Feature	Traditional Programming	AI Programming
Rule Definition	Explicitly written by humans	Learned from data
Adaptability	Fixed behavior	Learns and improves over time
Problem Solving	Deterministic	Probabilistic or heuristic
Intelligence	None	Simulates aspects of human intelligence

chatGPT

- **ChatGPT** is an advanced **AI language model** developed by **OpenAI**. It's designed to understand natural language (how humans speak and write) and generate human-like responses in real-time. GPT stands for **Generative Pre-trained Transformer**, and "Chat" refers to its ability to **converse interactively**, like chatting with a person.
- How it works in simple terms:

  Input: You ask it a question or give a prompt.

  Processing: It analyzes the words, context, and intent.

  Prediction: It predicts the next most likely words based on patterns it has learned.

  Output: It generates a natural-sounding and meaningful response.

Is ChatGPT Really Intelligent?

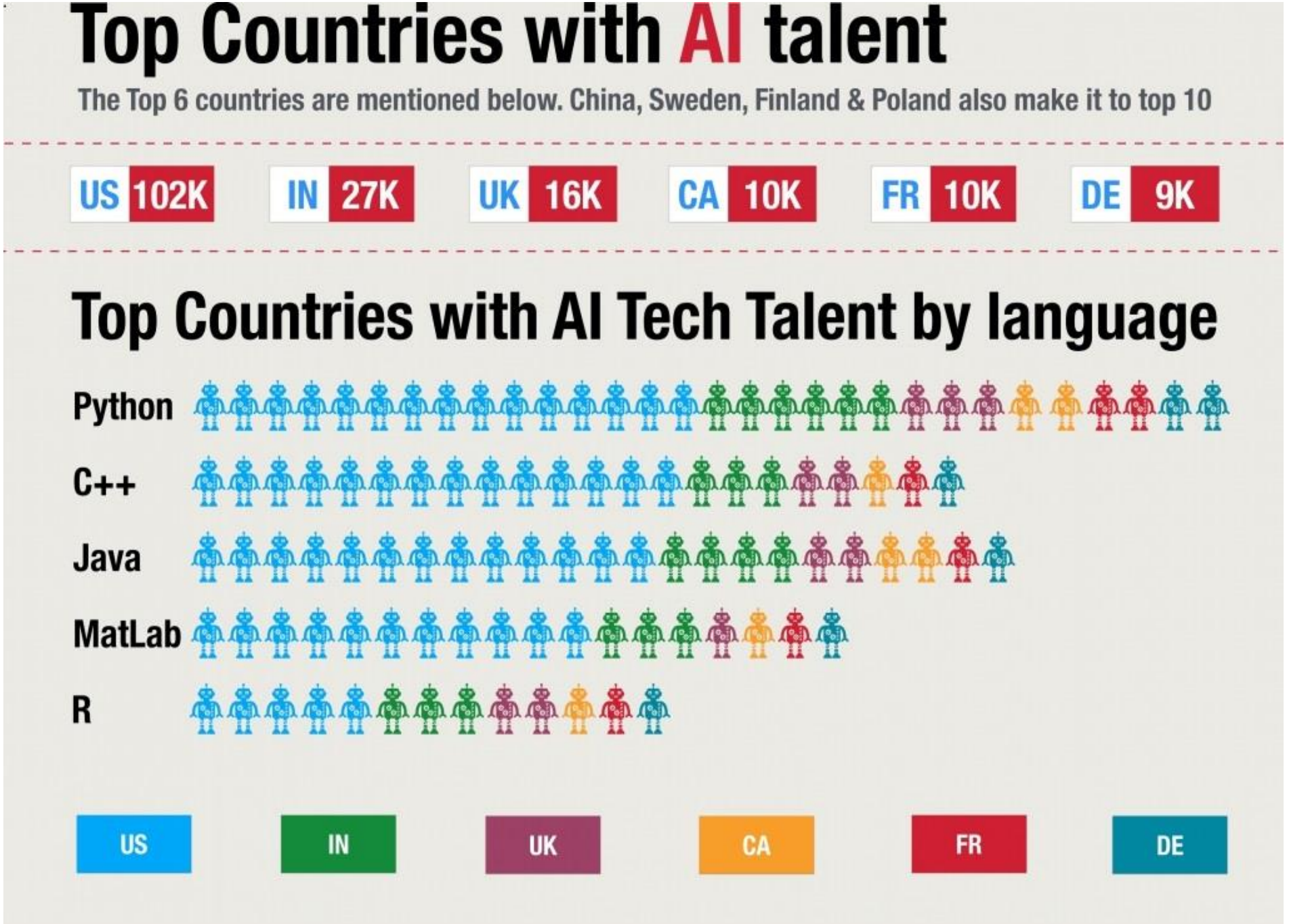
- ChatGPT is **not conscious** or **self-aware**. It doesn't "understand" language the way humans do—it uses **probabilistic predictions** based on training data. However, it can **simulate intelligent behavior** remarkably well, often fooling users into thinking it's "thinking."

Behind the Scenes

- **Model**: GPT-3.5 and GPT-4 are the most well-known versions.
- **Training**: Trained on billions of words from the internet.
- **Parameters**: GPT-4 has **trillions of parameters**, which are like virtual neurons that help it understand and generate language

ChatGPT vs Traditional Chatbots

Feature	ChatGPT	Rule-Based Chatbot
Training	Deep learning + big data	Predefined rules or scripts
Flexibility	High	Very limited
Learning	Learns from data	Cannot learn
Natural Language	Human-like	Often rigid or unnatural
Use Cases	Diverse	Narrow


Top Countries with AI talent
The Top 6 countries are mentioned below. China, Sweden, Finland & Poland also make it to top 10
US 102K
IN 27K
UK 16K
CA 10K
FR 10K
DE 9K
Top Countries with AI Tech Talent by language
Python
C++
Java
MatLab
R
US
IN
UK
CA
FR
DE

Top countries with the highest private investments in AI

Countries	Total investments from 2013-22
United States	248.9
China	95.11
United Kingdom	18.24
Israel	10.83
Canada	8.83
India	7.73
Germany	6.99
France	6.59
South Korea	5.57
Singapore	4.72
Japan	3.99
Hong Kong	3.1
Switzerland	3.04
Australia	3.04
Spain	1.81

Countries	Total investments in 2022
United States	47.36
China	13.41
United Kingdom	4.37
Israel	3.24
India	3.24
South Korea	3.1
Germany	2.35
Canada	1.83
France	1.77
Argentina	1.52
Australia	1.35
Singapore	1.13
Switzerland	1.04
Japan	0.72
Finland	0.61

*Figures are in US $ billion

THE PYPL POPULARITY OF PROGRAMMING LANGUAGE INDEX

Worldwide, Feb 2023 compared to a year ago:

Rank	Change	Language	Share	Trend
1		Python	27.7 %	-0.7 %
2		Java	16.79 %	-1.3 %
3		JavaScript	9.65 %	+0.6 %
4	↑	C#	6.97 %	-0.5 %
5	↓	C/C++	6.87 %	-0.6 %
6		PHP	5.23 %	-0.8 %
7		R	4.11 %	-0.1 %
8	↑↑	TypeScript	2.83 %	+0.8 %
9		Swift	2.27 %	+0.3 %
10	↓↓	Objective-C	2.25 %	-0.1 %
11	↑↑	Go	1.95 %	+0.7 %
12	↑↑	Rust	1.91 %	+0.9 %
13	↓	Kotlin	1.85 %	+0.2 %
14	↓↓↓	Matlab	1.71 %	-0.1 %
15	↑	Ruby	1.11 %	+0.3 %