# Artificial Intelligence

## Unit-1

**Introduction:** The Foundation of AI, The History of AI, The State of art. **Intelligent agents:** Agent and Environments, Good Behavior, Nature of Environments, Structure of Agents.

# Artificial Intelligence

Creating an intelligent machine which can behave like a human, think like a human and able to take decisions like a human.

## Definition of AI

"Intelligence: The ability to learn and solve problems"

Webster's Dictionary.

"Artificial intelligence (AI) is the intelligence exhibited by machines or software'

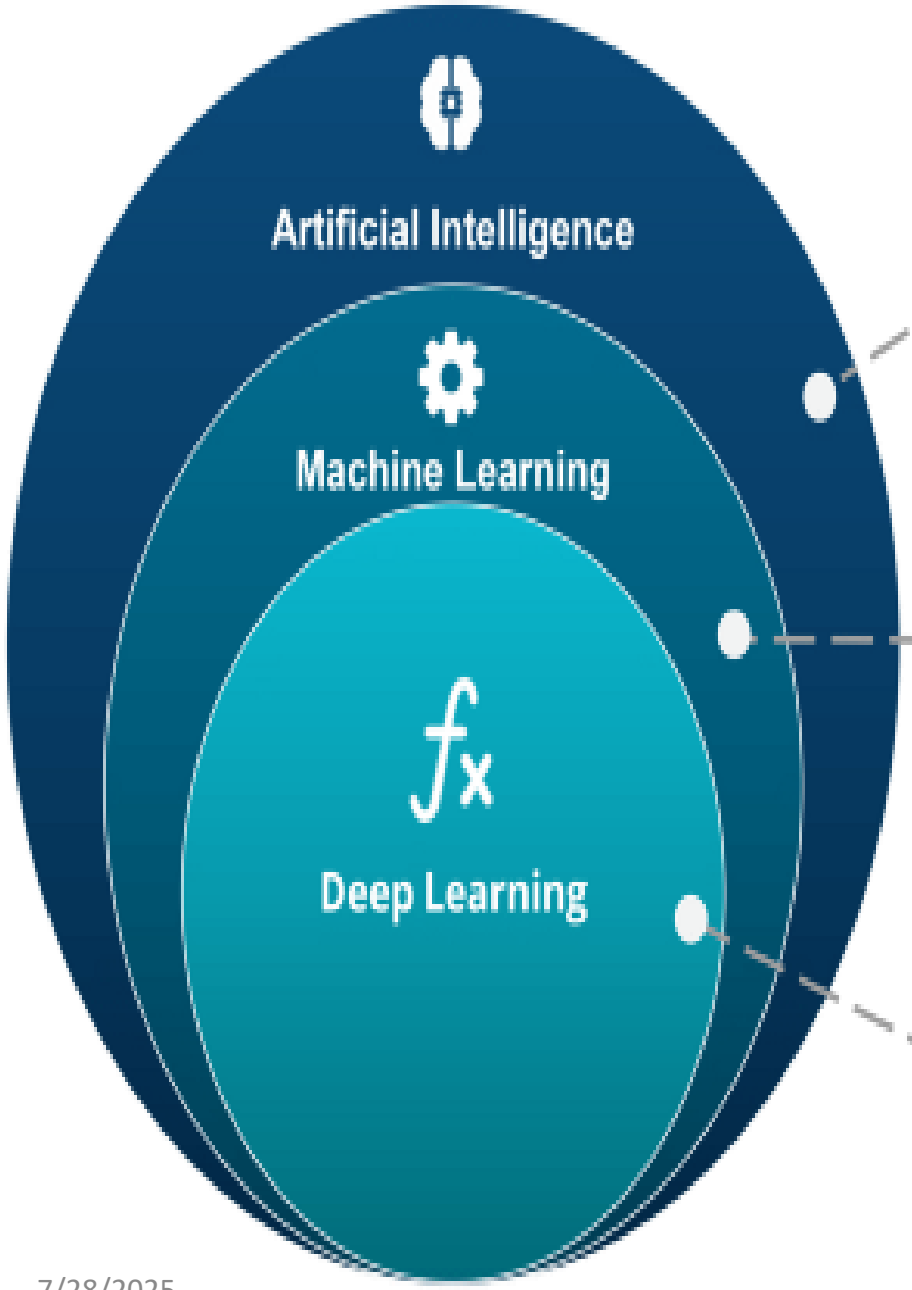
Wikipedia.

"The science and engineering of making intelligent machines"

McCarthy.

"The study and design of intelligent agents, where an intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success."

Russel and Norvig AI book.




## ARTIFICIAL INTELLIGENCE

A technique which enables machines to mimic human behaviour

## MACHINE LEARNING

Subset of AI technique which use statistical methods to enable machines to improve with experience

## DEEP LEARNING

Subset of ML which make the computation of multi-layer neural network feasible

# Why AI

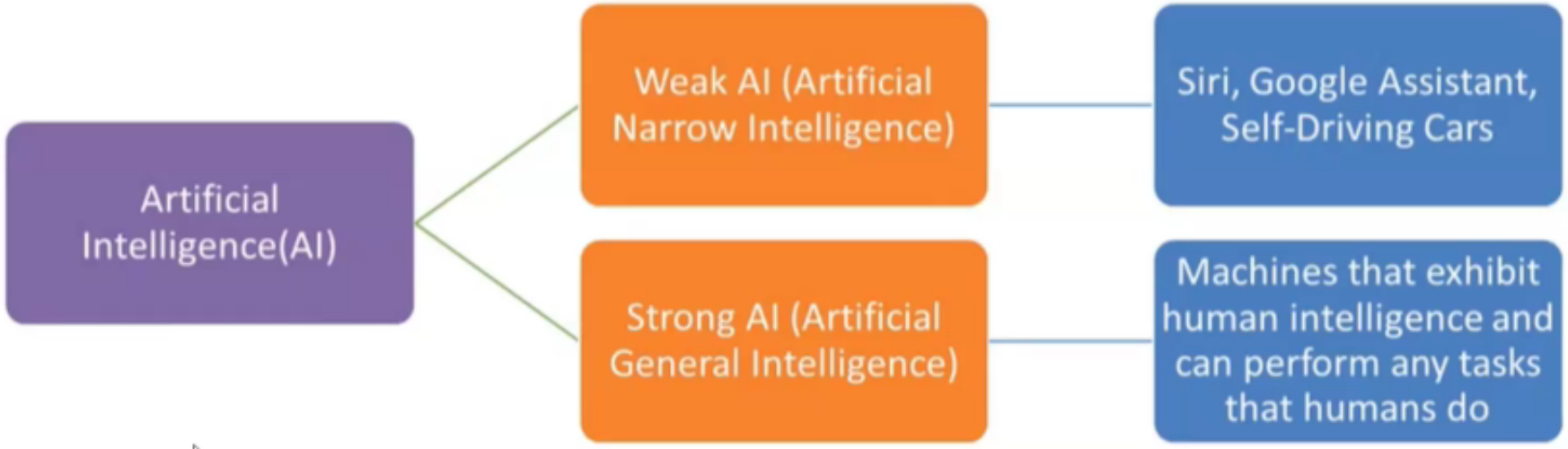
"Just as the Industrial Revolution freed up a lot of humanity from physical drudgery, I think AI has the potential to free up humanity from a lot of the mental drudgery."

Andrew Ng.

# Basic Computer capabilities to be acted as Human

1. **Natural language processing**: To communicate successfully in a human language
2. **Knowledge representation**: To store what it knows or hears
3. **Automated reasoning** to answer questions and to draw new conclusions
4. **Machine learning**: To adapt to new circumstances and to detect and extrapolate patterns.
5. **Computer vision and speech recognition**: To process the world
6. **Robotics**: To understand the environment and move about.

# Introduction to Artificial Intelligence



# Introduction to AI

Rational= mathematics+engineering

| Thinking Humanly | Thinking Rationally |
| --- | --- |
| "The exciting new effort to make computers think . . . *machines with minds,* in the full and literal sense." (Haugeland, 1985)<br><br>"[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning .. ." (Hellman, 1978) | "The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985)<br><br>"The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992) |
| **Acting Humanly** | **Acting Rationally** |
| "The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990)<br><br>"The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991) | "Computational Intelligence is the study of the design of intelligent agents." (Poole *et at,* 1998)<br><br>"Al . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998) |

Reasoning

Behaviour

# What is AI

## Thinking humanly: cognitive approach

Requires to determine how humans think!

1960's "cognitive revolution".

Requires scientific theories of internal activities of the brain

- What level of abstraction? "Knowledge" or "circuits"?
- How to validate?

**Today, Cognitive Science and Artificial Intelligence are distinct disciplines.**

Study of how the mind works

# Thinking rationally: The "laws of thought" approach

- **Right thinking**. (impossible to deny the reasoning process/logics)
- The Greek philosopher Aristotle was one of the first to attempt to reasoning in logic that involves drawing a conclusion from two premises. **(Syllogism)**

1. **Major Premise**: A general statement or universal truth.
2. **Minor Premise**: A specific statement related to the major premise.
3. **Conclusion**: The logical result derived from the two premises.

- **Major Premise**: All humans are mortal.
- **Minor Premise**: Socrates is a human.
- **Conclusion**: Therefore, Socrates is mortal.

The two main obstacles to using formal logical notation for computational reasoning are:

**1.Expressing Informal Knowledge**: It is challenging to convert informal knowledge into formal logical terms, especially when that knowledge is uncertain.

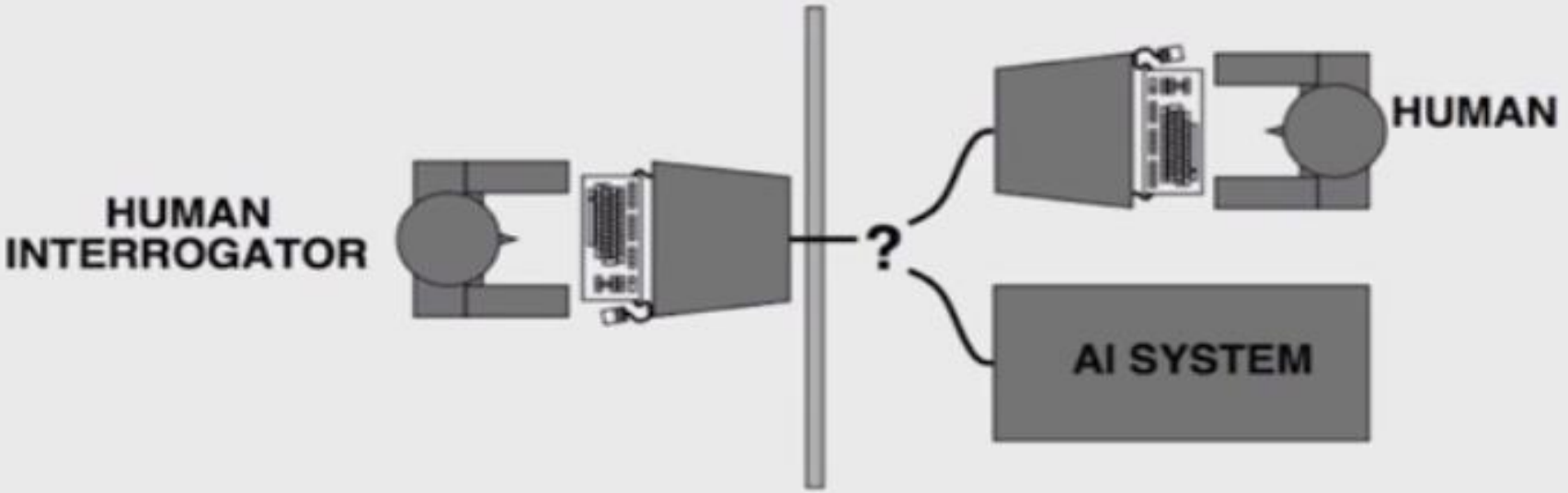
**2.Practical Problem Solving**: There is a significant difference between solving problems theoretically ("in principle") and actually implementing solutions in practice.

# What is AI?

machines do things...

## (2) Acting humanly:

- **Turing test (Alan Turing 1950)**: A computer passes the test of intelligence, if it can fool a human interrogator.




- **Major components of AI:** knowledge, reasoning, language, understanding, learning.

# What is AI?

## Acting humanly:

# What is AI?

## Acting rationally:

- The right thing: that which is expected to maximize goal achievement, given the available information.
- A **rational agent** is one that acts so as to achieve the best outcome, or when there is uncertainty, the best expected outcome.
- Aristotle (Nicomachean Ethics):
  *"Every art and every inquiry, and similarly every action and pursuit, is thought to aim at some good."*

# Applications of AI

Handwriting recognition (check, zipcode)

# Applications of AI

## Speech recognition

- Virtual assistants: Siri (Apple), Echo (Amazon), Google Now, Cortana (Microsoft).
- "They" helps get things done: send an email, make an appointment, find a restaurant, tell you the weather and more.
- Leverage deep neural networks to handle **speech recognition** and **natural language understanding**.

# Applications of AI

**Machine translation**

- Historical motivation: translate Russian to English.
- First systems using **mechanical translation** (one-to-one correspondence) failed!
- "Out of sight, out of mind" ⇒ "Invisible, imbecile".

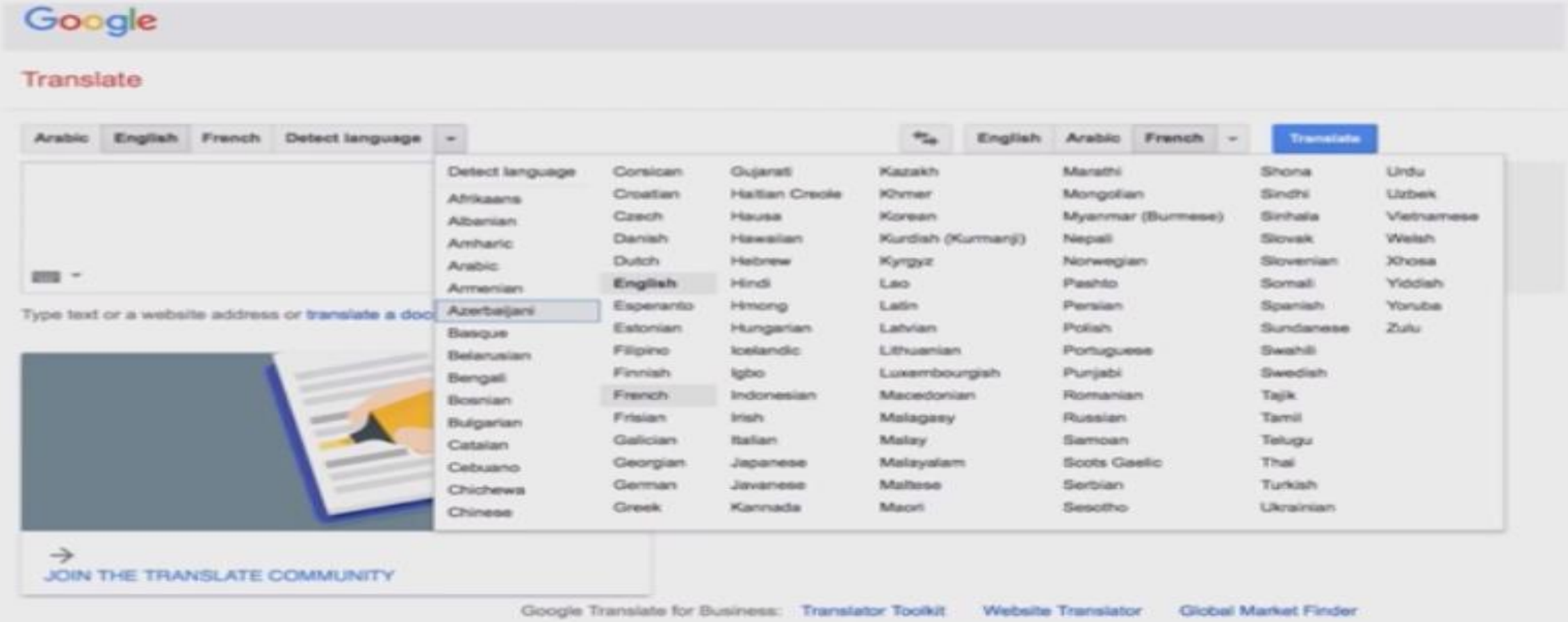
# Applications of AI

## Machine translation

- MT has gone through ups and downs.
- Today, **Statistical Machine Translation** leverages the vast amounts of **available translated corpuses**.
- While there is room for improvement, machine translation has made significant progress.

# Applications of AI

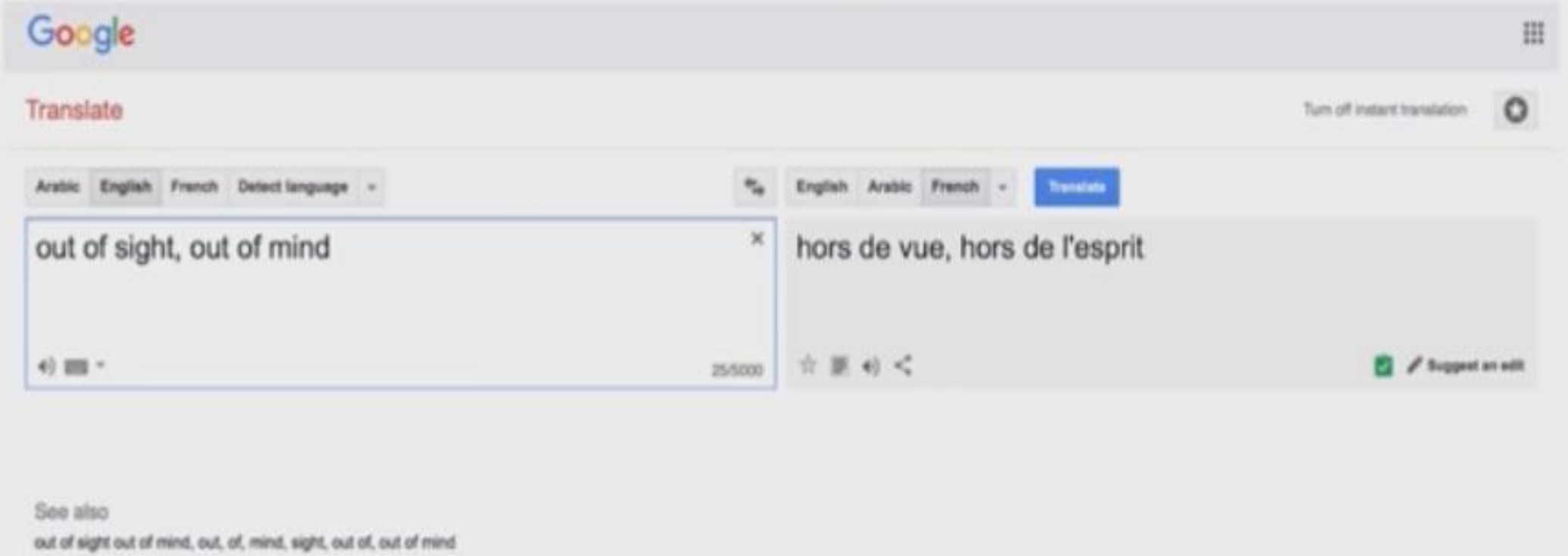
## Machine translation




**100+ languages**

# Applications of AI

## Machine translation



# Applications of AI

Robotics: Awesome robots today! NAO, ASIMO, and more!

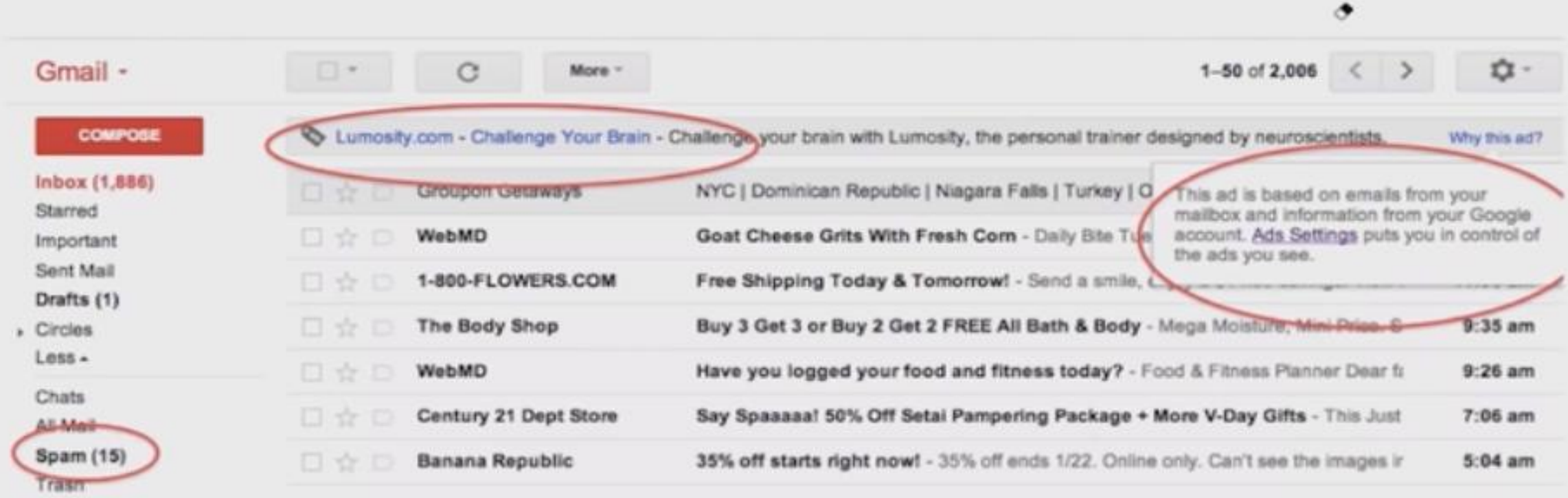

Credit: By Momotarou2012, via Wikimedia Commons.

# Applications of AI

## Recommendation systems (collaborative filtering)

# Applications of AI

## Email

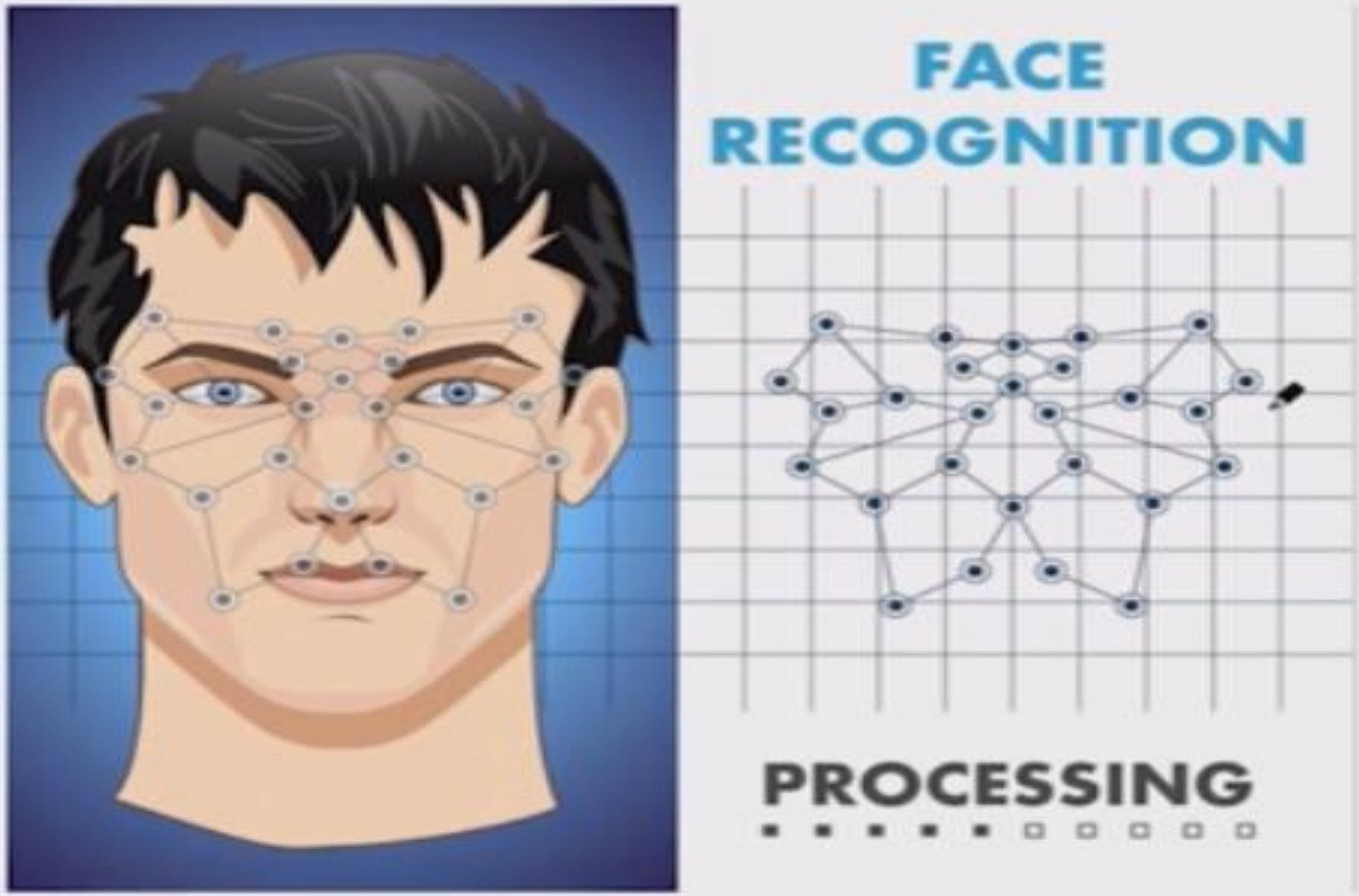


# Applications of AI

## Face detection

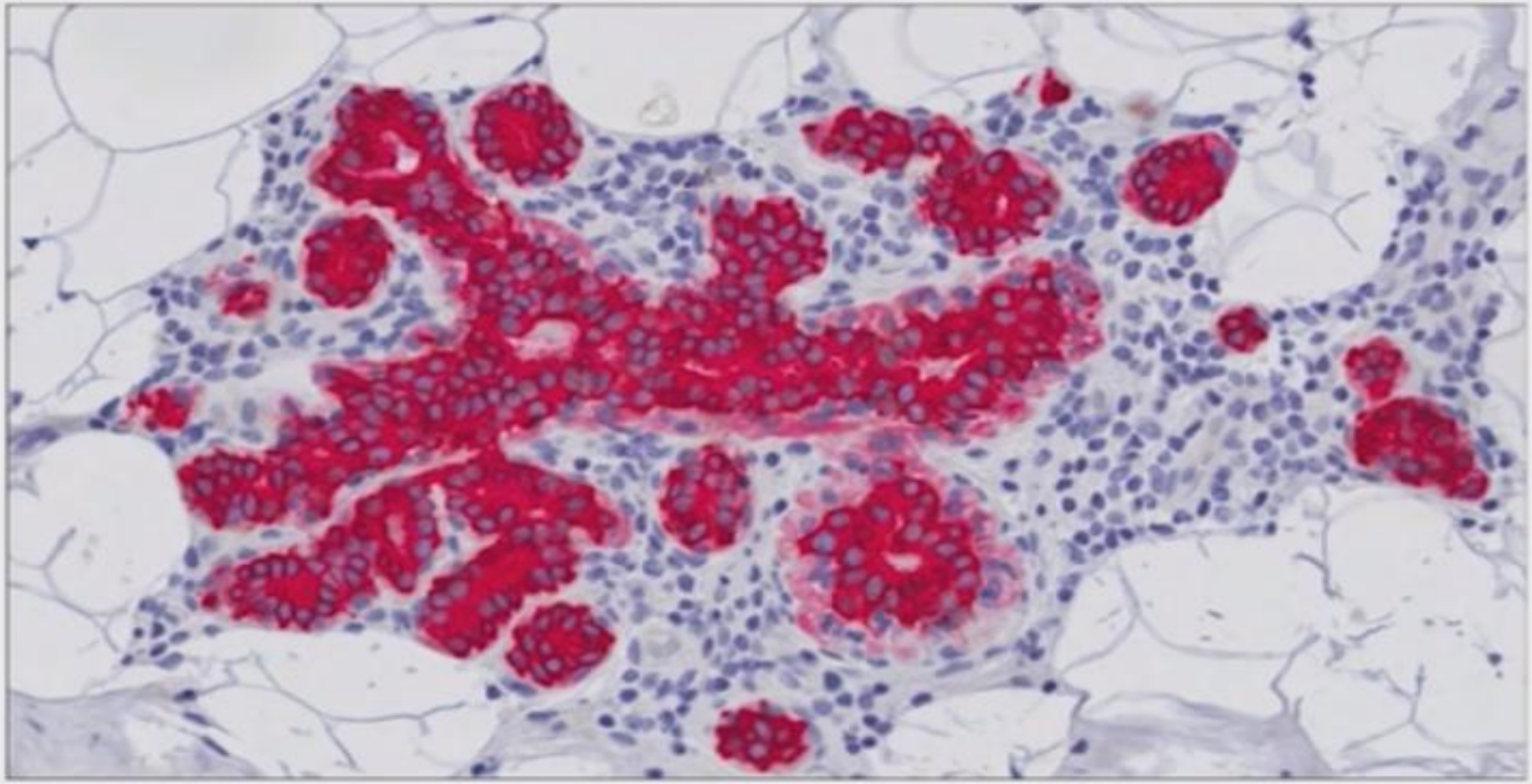
Viola-Jones method.

# Face recognition



# Applications of AI

Detection of breast cancer in mammography images



# Chess (1997): Kasparov vs. IBM Deep Blue

(Left) Copyright 2007, S.M.S.I., Inc. - Owen Williams, The Kasparov Agency, via Wikimedia Commons (Right) By James the photographer, via Wikimedia Commons

Powerful search algorithms!

# Jeopardy! (2011): Humans vs. IBM Watson

By Rosemaryetoufee (Own work), via Wikimedia Commons

Natural Language Understanding and information extraction!

# Autonomous driving

By User Spaceape on en.wikipedia, via Wikimedia Commons

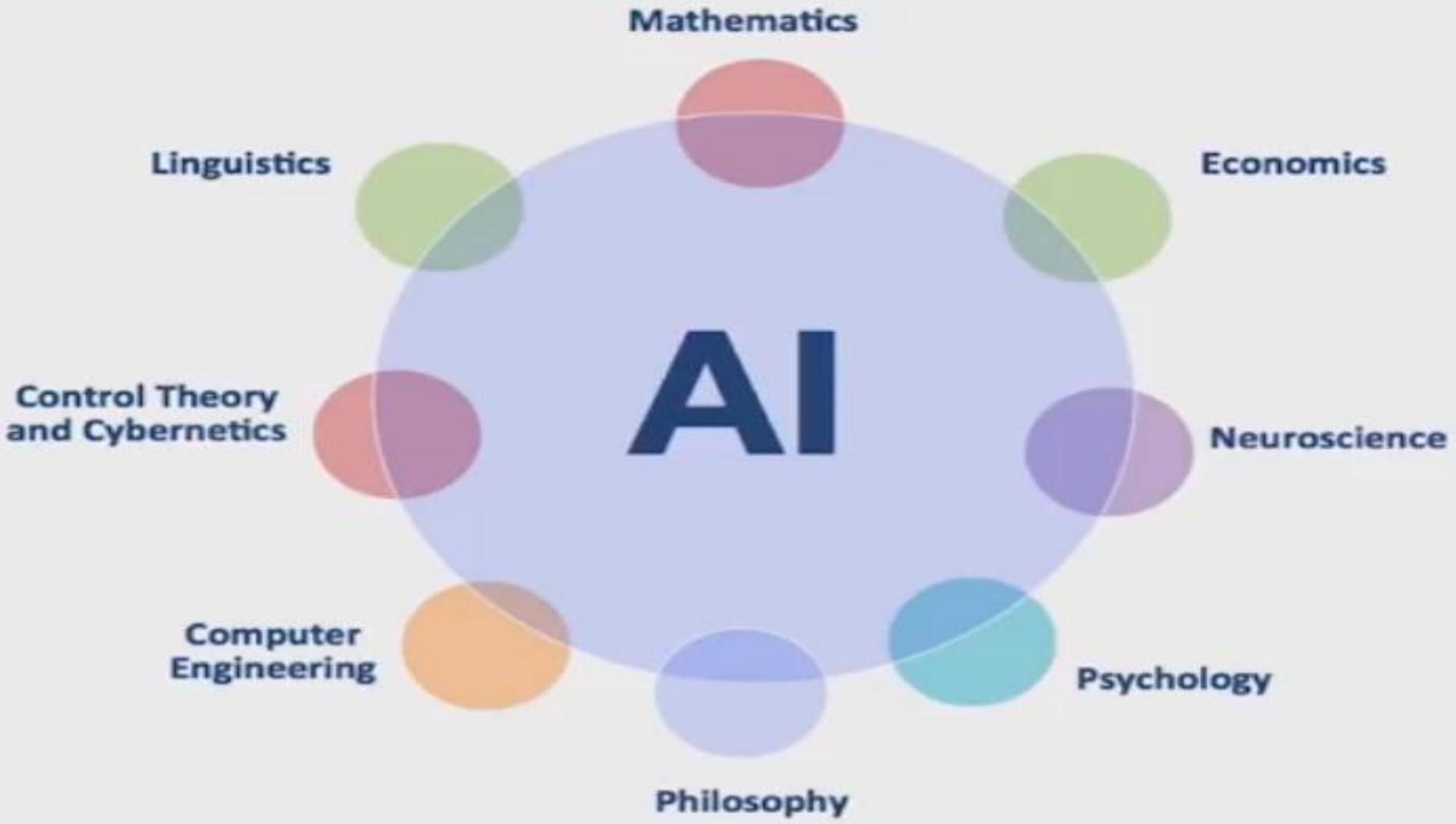
- DARPA Grand Challenge
  - 2005: 132 miles
  - 2007: Urban challenge
  - 2009: Google self-driving car

# Applications

- **Natural Language Processing (NLP)**: concerned with the interactions between computers and human languages.
- **Vision/perception**: concerned with image processing and building computer vision agents. Goals: information extraction for tasks such as manipulation, navigation, and object recognition.
- **Robotics**: concerned with intelligent agents that manipulate the physical world. Different aspects: planning of robot motion, vision and object recognition.

# Foundation of AI

(Disciplines that contributed to AI)



# Foundation of AI

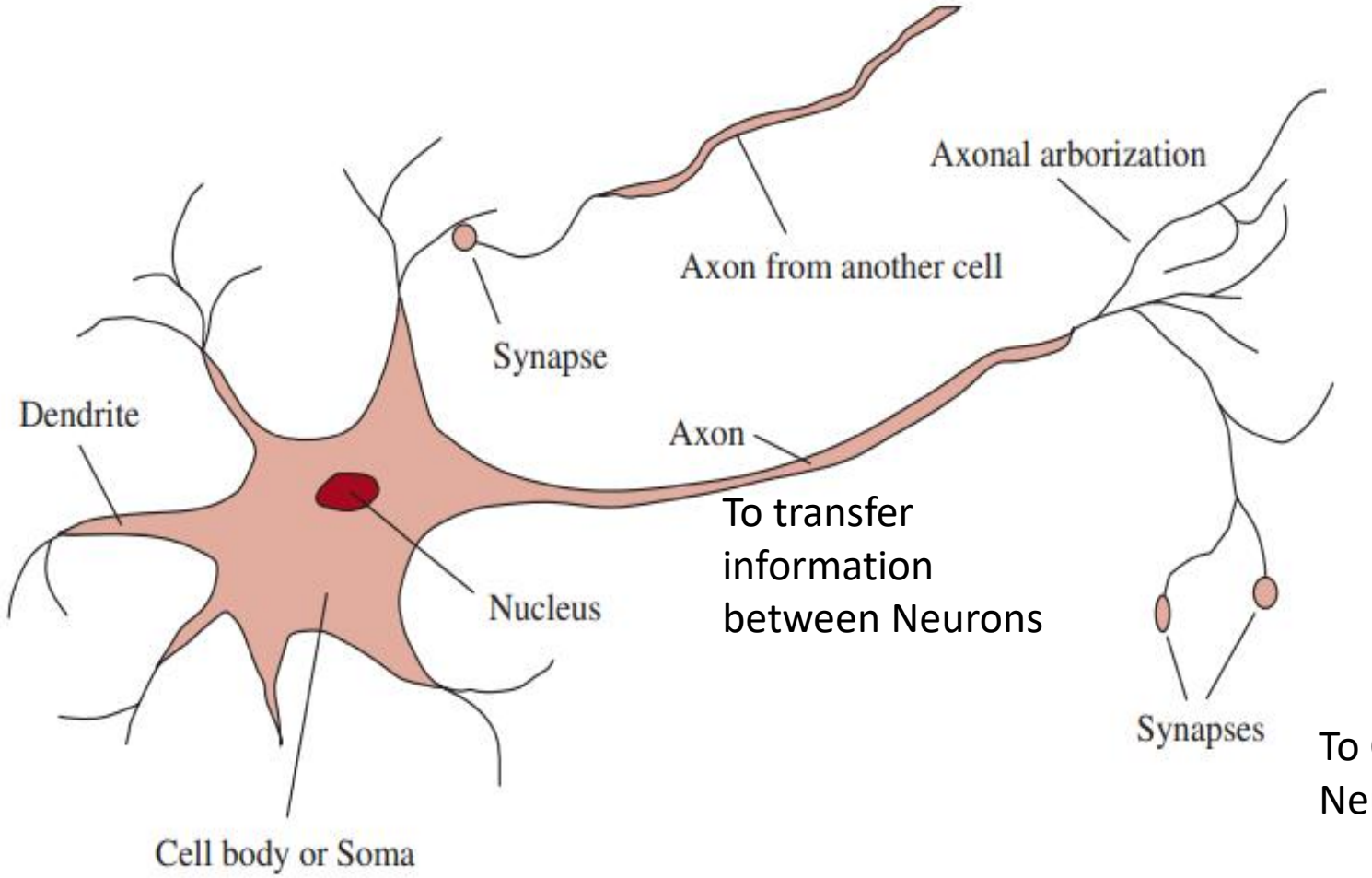
- **Philosophy** Basic foundation, usage of formal rules to draw conclusions
  - Logic, methods of reasoning. Knowledge and mind(brain)
  - Mind as physical system that operates as a set of rules.
  - Foundations of learning, language, rationality.
- **Mathematics** Logic, Probability, computation
  - Logic: Formal representation and proof.
  - Computation, algorithms.
  - Probability.
- **Economics** Low Investing and maximizing utility
  - Formal theory of rational decisions.
  - Combined decision theory and probability theory for decision making under uncertainty.
  - Game theory.
  - Markov decision processes. How agent behaves in diff. situations to achieve goal

# Foundation of AI

- **Neuroscience** Study of Human brain and nervous system
  - Study of brain functioning.
  - How brains and computers are (dis)similar.
- **Psychology** Cognitive science
  - How do we think and act?
  - Cognitive psychology perceives the brain as an information processing machine.
  - Led to the development of the field *cognitive science*: how could computer models be used to study *language*, *memory*, *and thinking* from a psychological perspective.
- **Computer engineering** Super computers, GPUs, Quantum computers
  - Cares about how to build powerful machines to make AI possible. Super computers, Quantum computers
  - E.g., Self-driving cars are possible today thanks to advances in computer engineering

# Biological Neuron

Branches of cell




To transfer information between Neurons

To Connect with Neuron

# Foundation of AI

System interactions

- **Control theory and cybernetics** System analyse, define, debug and fix errors by itself
  - Design simple optimal agents receiving feedback from the environment.
  - Modern control theory design systems that maximize an objective function over time. Self controlling machines

- **Linguistics** Speech to text and text to speech
  - How are language and thinking related.
  - Modern linguistics + AI = Computational linguistics (Natural language processing).


## Birth of AI

### 1952-1956

In the 1940s and 50s, a handful of scientists from a variety of fields (mathematics, psychology, engineering, economics and political science) began to discuss the possibility of creating an artificial brain.

## Symbolic AI

- The programs developed in the years after the Dartmouth Workshop were,
- Computers were solving algebra word problems, proving theorems in geometry and learning to speak English.

### 1956-1974

Tech and data limitations reduced

## AI Winter

### 1974-1980

- Limited Computer Power
- There are many problems that can probably only be solved in exponential time
- Can still only handle trivial versions of the problems.
- The end of funding

Knowledge revolution,

## Boom

- Rise of Expert Systems
- The Knowledge Revolution
- The Money Return

### 1980-1987

No significant developments recorded

## Bust : 2nd AI Winter

### 1987-1993

The collapse was due to the failure of commercial vendors to develop a wide variety of workable solutions.As dozens of companies failed, the perception was that the technology was not viable

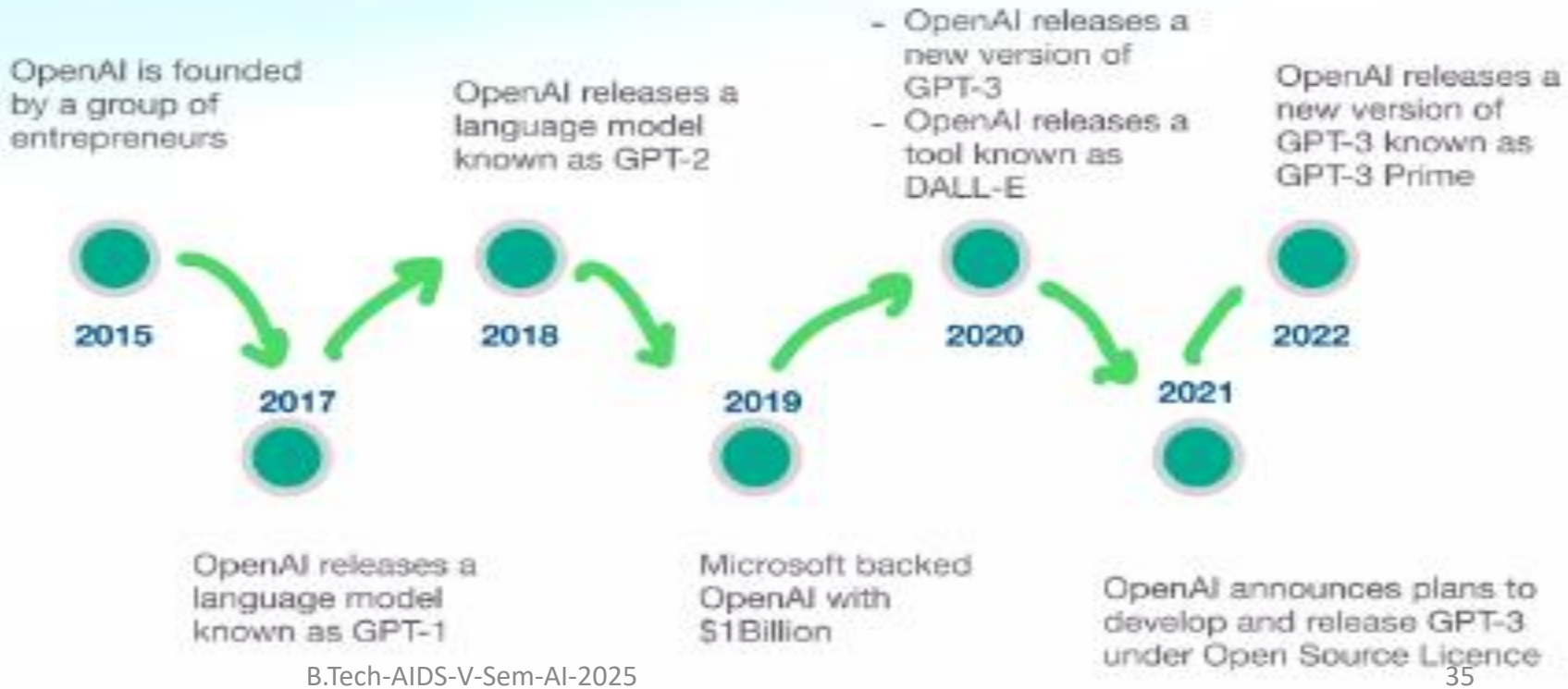
# AI Renaissance

- AI was both more cautious and more successful than it had ever been.
- Deep Blue became the first computer chess-playing system

## 1993-2011

# Deep learning, big data and artificial general intelligence (AGI)

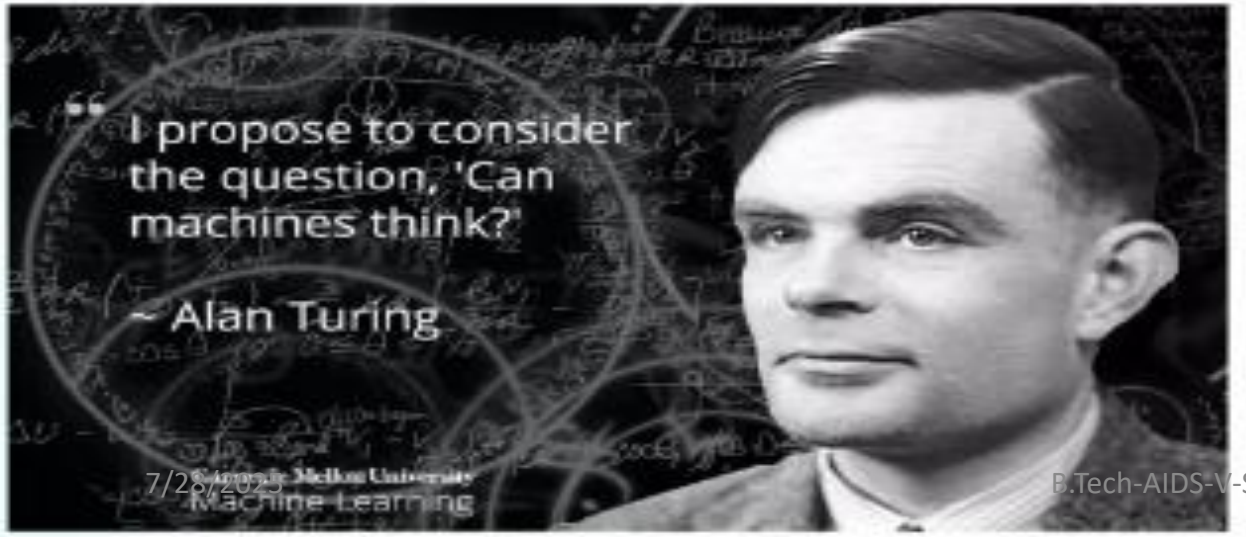
## 2011- Present



# 1950 - Alan Turing

## Can Machine Think?

1950: Alan Turing publishes "Computing Machinery and Intelligence" which proposes the Turing Test, a method for determining whether a machine can exhibit intelligent behaviour equivalent to, or indistinguishable from, that of a human.




Computing Machinery and Intelligence

A. M. Turing

1950

**1 The Imitation Game**

I propose to consider the question, "Can machines think?" This should begin with definitions of the meaning of the terms "machine" and "think." The definitions might be framed so as to reflect so far as possible the normal use of the words, but this attitude is dangerous. If the meaning of the words "machine" and "think" are to be found by examining how they are commonly used it is difficult to escape the conclusion that the meaning and the answer to the question, "Can machines think?" is to be sought in a statistical survey such as a Gallup poll. But this is absurd. Instead of attempting such a definition I shall replace the question by another, which is closely related to it and is expressed in relatively unambiguous words.

https://web.iitd.ac.in/~sumeet/Turing50.pdf

Alan Turing: Turing test

# 1956 - John McCarthy

Dartmouth Conference: Coined the term AI

## Birth of AI

1956: John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon organize the **Dartmouth** Conference, which is considered to be the birth of AI as a field. The conference defines the goals of AI research and lays the groundwork for the development of early AI systems.


# 1958 - John McCarthy

## Lisp - Designed for AI

1958: John McCarthy invents Lisp, a programming language designed specifically for AI research.

Recursive Functions of Symbolic Expressions and Their Computation by Machine, Part I

John McCarthy, Massachusetts Institute of Technology, Cambridge, Mass. *

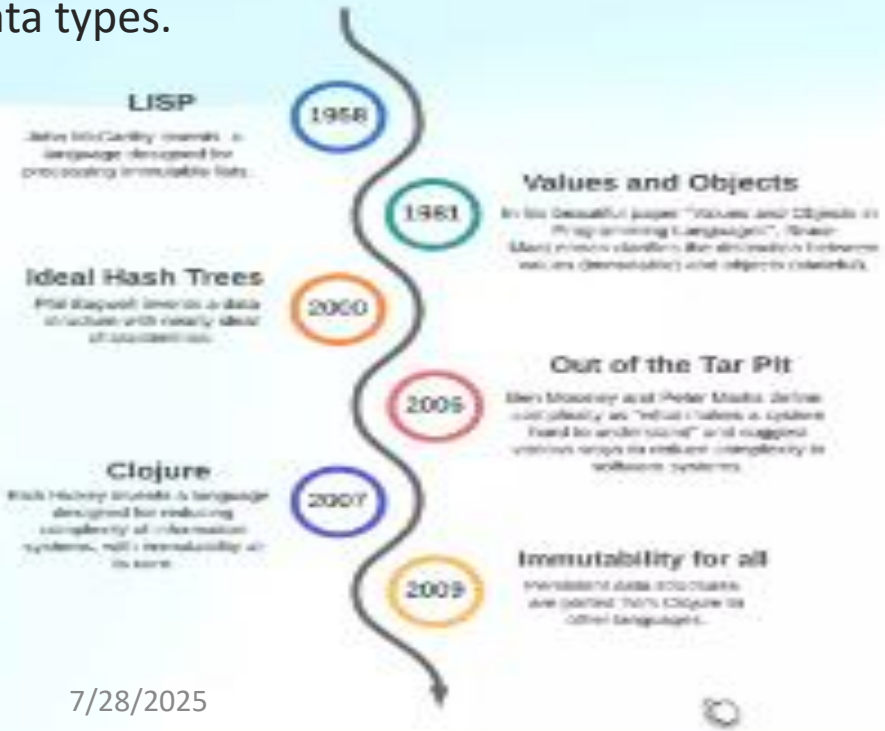
April 1960

1 Introduction

A programming system called LISP (for LISt Processor) has been developed for the IBM 704 computer by the Artificial Intelligence group at M.I.T. The system was designed to facilitate experiments with a proposed system called the Advice Taker, whereby a machine could be instructed to handle declarative as well as imperative sentences and could exhibit "common sense" in carrying out its instructions. The original proposal [1] for the Advice Taker was made in November 1958. The main requirement was a programming system for manipulating expressions representing formalized declarative and imperative sentences so that the Advice Taker system could make deductions.

http://www-formal.stanford.edu/jmc/recursive.pdf

Expression based language, dynamic typing, supports many data types.



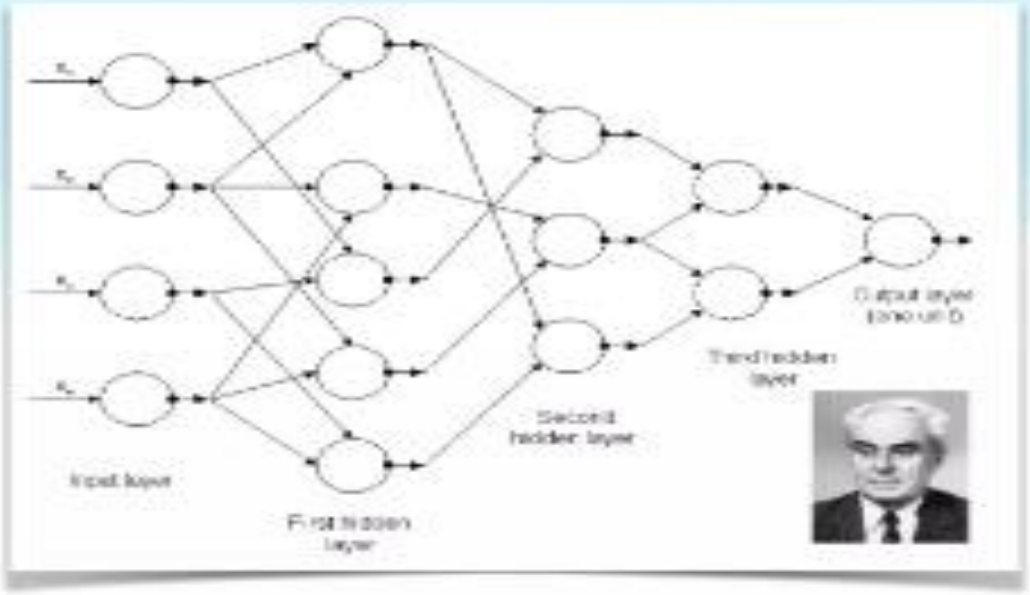
# 1965 - Anatolii Gershman, Alexey Ivakhnenko, Valentin La

## Deep Learning - Multi Layered Perceptron

1965 : **The Group Method of Data Handling** (GMDH) is a data-driven approach to modeling that is based on a multi-layered architecture of interconnected polynomial models.

A multi-layer perceptron (MLP) is a type of artificial neural network (ANN) that is composed of multiple layers of interconnected nodes, or "neurons". MLPs are typically used for supervised learning tasks, such as classification and regression.

Ivakhnenko is often considered as the father of **deep learning.**



# Chess (1997): Kasparov vs. IBM Deep Blue

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Powerful search algorithms!

# 2014-18 : Google acquires DeepMind

2009

## Development of Deep Learning Algorithms

**2014**: Facebook creates its AI research division, and Google acquires DeepMind, an AI company that later develops the AlphaGo system that beats the world champion in the game of Go.

**2016**: Google's AlphaGo defeats world champion Lee Sedol in a five-game match.

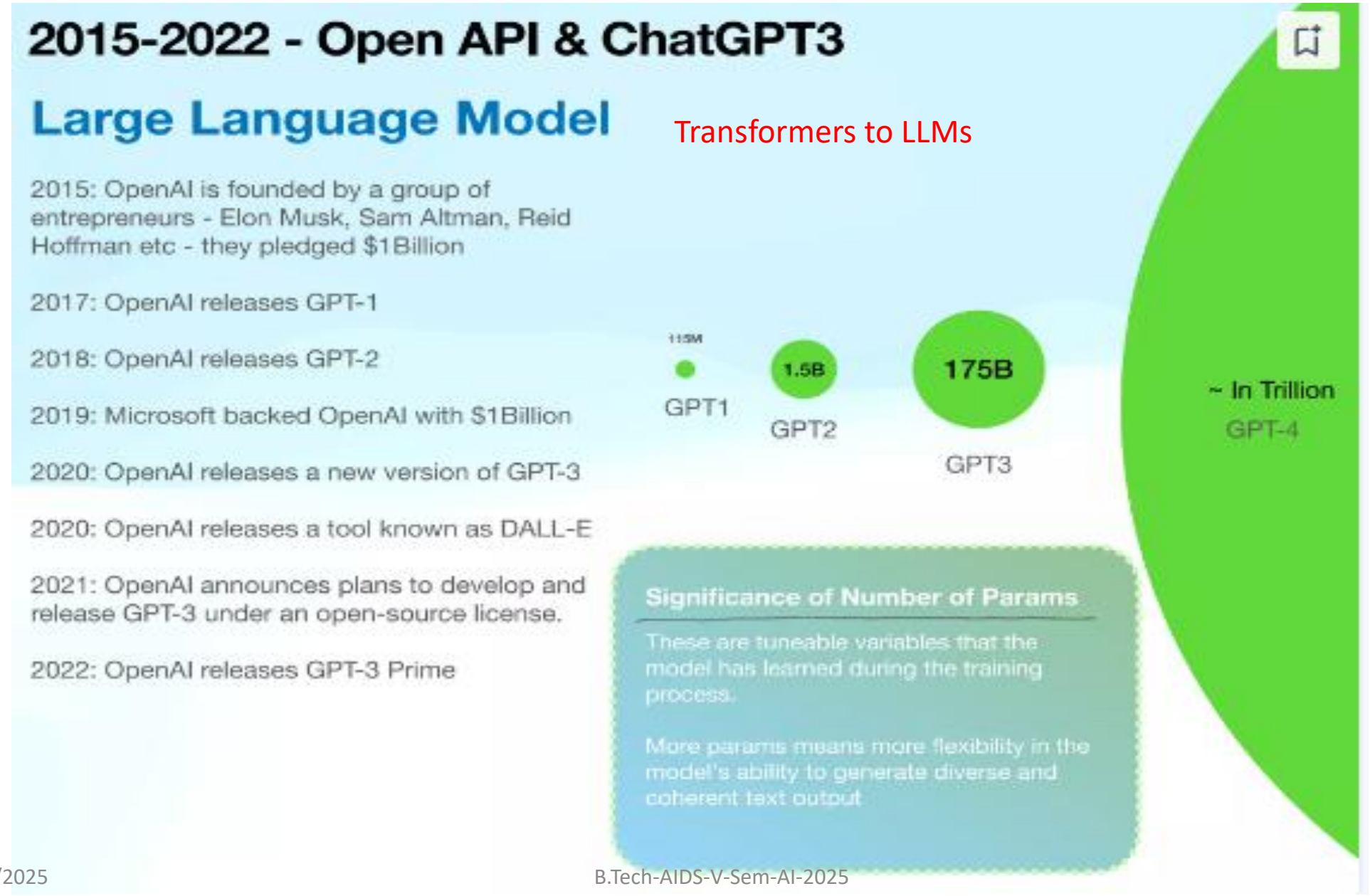
**2018**: The development of deep learning algorithms for natural language processing leads to significant improvements in machine translation and other language-based AI applications.


against the legendary Lee Sedol


https://techcrunch.com/2014/01/26/google-deepmind/

- The **emergence of intelligent agents** like in the **Year 1997**: **IBM Deep Blue** beats world chess champion, Gary Kasparov, and became the first computer to beat a world chess champion.
- **Year 2002:** for the first time, AI entered the home in the form of **Roomba, a vacuum cleaner.**
- **Year 2006:** AI came in the Business world. Companies like Facebook, Twitter, and Netflix also started using AI.
- **Year 2011: IBM's Watson won jeopardy**, Google now, Chatbot "Eugene Goostman" won a competition in the famous "Turing test." etc.
- Year 2017: **Google Brain** introduced **Transformers** in NLP to process text.

# GPT stands for Generative Pre-training Transformer.



# The State of art

- **Robotic Vehicles**

**STANLEY's Achievement**:

- **In 2005, STANLEY, a driverless robotic car**, completed the DARPA Grand Challenge, traveling 132 miles through the Mojave Desert at 22 mph.
- STANLEY is a Volkswagen Touareg equipped with cameras, radar, and laser rangefinders for environmental sensing, along with onboard software for steering, braking, and acceleration control.

**CMU's Boss: (**Carnegie Mellon University)

- **In 2006, robotic vehicle, Boss, won the Urban Challenge**. Boss successfully navigated through traffic in a closed Air Force base, adhering to traffic rules and avoiding pedestrians and other vehicles.

- **Machine Translation:** A computer program automatically **translates from Arabic to English**.
- **Speech Recognition : United Airlines** used aautomated speech recognition and dialog management system to book flights.

# The State of art

- **Autonomous Planning and Scheduling**
  - **NASA's Remote Agent program** was the first onboard autonomous planning system, **controlling spacecraft operations** a hundred million miles from Earth.
  - The successor to the Remote Agent program, **MAPGEN**, is responsible for **planning daily operations for NASA's Mars Exploration** Rovers.
  - **MEXAR2 conducted mission planning** for the European Space Agency's Mars Express mission in 2008, **encompassing both logistics and scientific planning**
- **Game Playing**
  - **IBM's Deep Blue** was the first computer program to **defeat a world chess champion**, Garry Kasparov, in an exhibition match.
  - Newsweek referred to the match as "The brain's last stand," reflecting the significance of this event in the context of human versus machine intelligence. IBM's stock value increased by $18 billion.

- **Spam Fighting**
  - **Learning algorithms classify over a billion messages daily as spam**, significantly reducing the time recipients spend deleting unwanted emails.
  - Spammers continuously update their tactics, making it challenging for static programmed approaches to effectively combat spam.
- **Logistics planning:**
- During the Persian Gulf crisis of 1991, **U.S. forces deployed a Dynamic Analysis and Replanning Tool**, **DART** (Cross and Walker, 1994), to do automated logistics planning and scheduling for transportation.
- This involved up to 50,000 vehicles, cargo, and people at a time, and had to account for starting points, destinations. routes, and conflict resolution among all parameters. The AI planning techniques generated in hours a plan that would have taken weeks with older methods.
- **Robotics:**
- **The iRobot Corporation has sold over two million Roomba robotic vacuum cleaners** for home use.
- **PackBot,** where it is used **to handle hazardous materials**, clear explosives, and **identify the location of snipers.** (For Iraq and Afghanistan)

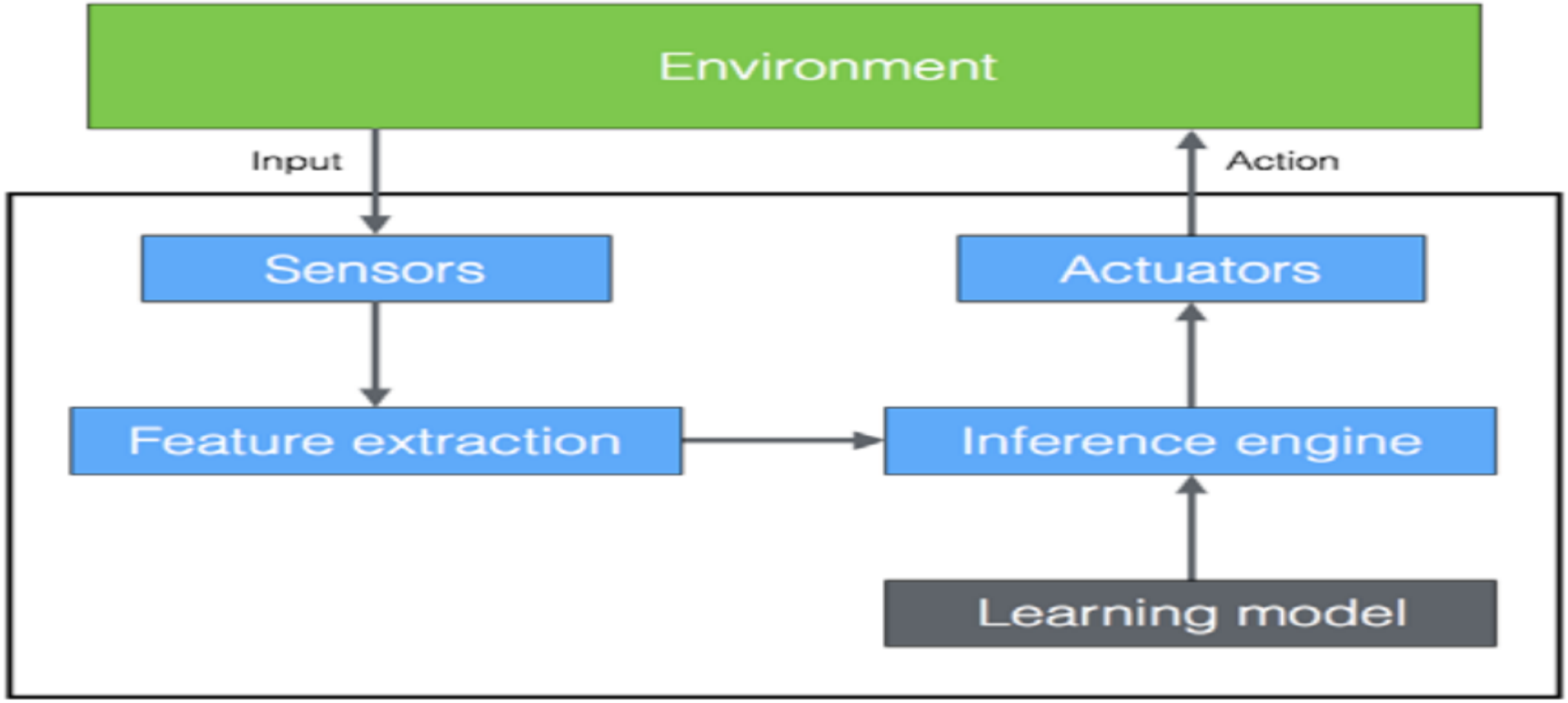
# State-of-the-art applications

- Speech recognition
- Autonomous planning and scheduling
- Financial forecasting
- Game playing, video games
- Spam fighting
- Logistics planning
- Robotics (household, surgery, navigation)
- Machine translation
- Information extraction
- VLSI layout
- Automatic assembly
- Sentiment analysis
- Fraud detection
- Recommendation systems
- Web search engines
- Autonomous cars
- Energy optimization
- Question answering systems
- Social network analysis
- Medical diagnosis, imaging
- Route finding
- Traveling salesperson
- Protein design
- Document summarization
- Transportation/scheduling
- Computer animation

1. Rational intelligent agents
2. Search agents (uninformed search, informed search)
3. Adversarial search/games
4. Machine Learning (ML)
5. Constraint satisfaction problems (CSPs)
6. Logic (propositional logic, first order logic)
7. Markov Decision Processes (MDPs) and Reinforcement Learning (RL)
8. Application to Natural language Processing (NLP)
9. Application to vision and robotics

**An artificial intelligence (AI) agent refers to a system or program that is capable of autonomously performing tasks on behalf of a user**

# Agent



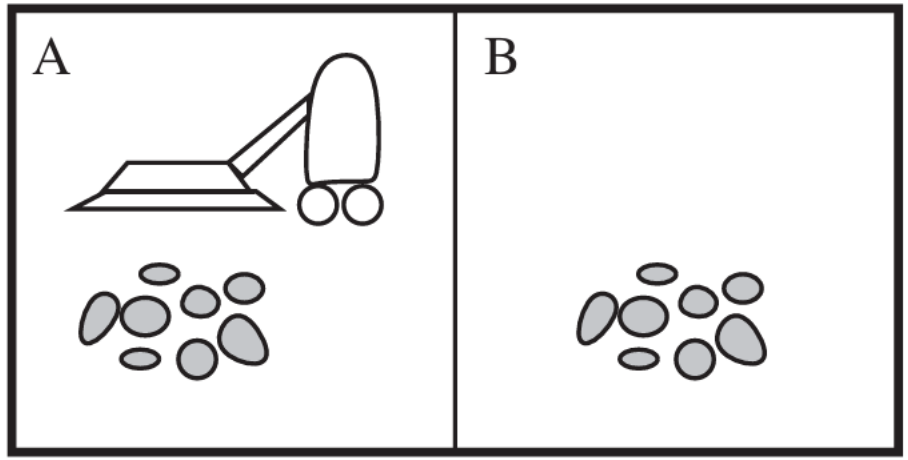

**Intelligent agent**

# Agents and Environments

- An **agent** is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators.
- Percept: **agent's perceptual inputs** at any given instant.
- **Percept Sequence**: complete history of everything the agent has ever perceived.
- An agent's choice of action at any given instant can depend on its built-in knowledge and on the entire percept sequence observed to date, but not on anything it hasn't perceived.
- **Agent's behavior**: is described by the agent function.
- **Agent function**: is an abstract mathematical description
- **Agent program**: is a concrete implementation, running within some physical system.

# Example: Vacuum-cleaner world

- Perception: Clean or Dirty? where it is in?
- Actions: Move left, Move right, suck, do nothing




| Percept Sequence | Action |
|---|---|
| [A, Clean] | Right |
| [A, Dirty] | Suck |
| [B, Clean] | Left |
| [B, Dirty] | Suck |
| [A, Clean], [A, Clean] | Right |
| [A, Clean], [A, Dirty] | Suck |
| . . . | . . . . . |

**Agent = architecture + program**

Architecture :device with sensors and actuators (e.g., A robotic car, a camera, a PC)

# Good Behavior: The concept of Rationality

- A **rational agent** is one that does the right thing—conceptually speaking, every entry in the table for the agent function is filled out correctly.
- **Need of performance measure**: A performance measure is an objective criterion for success of an agent's behavior.
- **Example**: Performance measure of a vacuum cleaner agent could be amount of dirt cleaned up, amount of time taken, amount of electricity consumed, amount of noise generated, etc.

**Rationality:**

- The **performance measure** that defines degree of success.(no.of squares it has taken for clean-up)
- Everything that the agent has perceived so far. We will call this complete perceptual history the percept sequence.
- What the agent knows about the environment. (Priori(Unknown Location))
- The actions that the agent can perform. (Left, Right , and Suck)

- **Rationality** is about making the best decisions possible given the agent's current information and capabilities.
- **Omniscience** means having unlimited, all-knowing intelligence and awareness.
- Rational agent not only to gather information but also to **learn** as much as possible from what it perceives.
- To the extent that an agent relies on the prior knowledge of its designer rather than on its own percepts, we say that the agent lacks **autonomy**.
- A rational agent should be **autonomous**—it should learn what it can to compensate for partial or incorrect prior knowledge.

# The Nature of Environments

- **Task environments**, which are essentially the "**problems**" to which **rational agents** are the "**solutions**."
- For an agent (Vacuum cleaner), we had to specify the performance measure, the environment, and the agent's actuators and sensors. This is called **Task environment.**
- Acronymically, we call this the **PEAS (Performance, Environment, Actuators, Sensors)**

| Agent Type | Performance Measure | Environment | Actuators | Sensors |
|---|---|---|---|---|
| Taxi driver | Safe, fast, legal, comfortable trip, maximize profits | Roads, other traffic, pedestrians, customers | Steering, accelerator, brake, signal, horn, display | Cameras, sonar, speedometer, GPS, odometer, accelerometer, engine sensors, keyboard |

**Figure 2.4** PEAS description of the task environment for an automated taxi.

| Agent Type | Performance Measure | Environment | Actuators | Sensors |
|---|---|---|---|---|
| Medical diagnosis system | Healthy patient, reduced costs | Patient, hospital, staff | Display of questions, tests, diagnoses, treatments, referrals | Keyboard entry of symptoms, findings, patient's answers |
| Satellite image analysis system | Correct image categorization | Downlink from orbiting satellite | Display of scene categorization | Color pixel arrays |
| Part-picking robot | Percentage of parts in correct bins | Conveyor belt with parts; bins | Jointed arm and hand | Camera, joint angle sensors |
| Refinery controller | Purity, yield, safety | Refinery, operators | Valves, pumps, heaters, displays | Temperature, pressure, chemical sensors |
| Interactive English tutor | Student's score on test | Set of students, testing agency | Display of exercises, suggestions, corrections | Keyboard entry |

**More examples of agent types and their PEAS descriptions**

**Softbots: Software-based Intelligent Agents,** are a type of artificial agent that exists and operates solely in a digital, software-based environment.

**Properties of task environments:**

- **Fully observable vs. partially observable**: If an agent's sensors give it access to the complete state of the environment, un observable sometimes. (Chess Vs Poker)
- **Single agent vs. multiagent**: Single agent operates independently, multiagent involves multiple autonomous agents interacting with each other. (crossword puzzle vs chess)
- **Deterministic vs. stochastic**: if the next state is completely determined by the current state and the agent's action, stochastic if the next state is determined probabilistically. (Tic-tac-toe vs. Weather forecasting)
- **Episodic vs. sequential:** if the agent's experience is divided into discrete, independent episodes, sequential if the agent's experience is a continual sequence of states, actions. (Medical diagnosis vs. Robot navigating a maze)

- **Static vs. dynamic:** if the environment does not change while the agent is deliberating, dynamic if the environment changes independently of the agent. (Pieces puzzle solving Vs. Online shopping)
- **Discrete vs. continuous:** The environment has a finite no.of distinct states and actions, continuous has infinite no.of distinct states and actions (Chess vs taxi driving)
- **Known vs. unknown:** The agent has complete knowledge of the environment, including the possible states, actions, transition model, and reward function. Otherwise, unknown. (Monopoly Vs. Self driving car navigating in new city)

- It is quite possible for a known environment to be partially observable—for example, in solitaire card games, I know the rules but am still unable to see the cards that have not yet been turned over.
- Conversely, an unknown environment can be fully observable—in a new video game, the screen may show the entire game state but I still don't know what the buttons do until I try them.

| Task Environment | Observable | Agents | Deterministic | Episodic | Static | Discrete |
|---|---|---|---|---|---|---|
| Crossword puzzle | Fully | Single | Deterministic | Sequential | Static | Discrete |
| Chess with a clock | Fully | Multi | Deterministic | Sequential | Semi | Discrete |
| Poker | Partially | Multi | Stochastic | Sequential | Static | Discrete |
| Backgammon | Fully | Multi | Stochastic | Sequential | Static | Discrete |
| Taxi driving | Partially | Multi | Stochastic | Sequential | Dynamic | Continuous |
| Medical diagnosis | Partially | Single | Stochastic | Sequential | Dynamic | Continuous |
| Image analysis | Fully | Single | Deterministic | Episodic | Semi | Continuous |
| Part-picking robot | Partially | Single | Stochastic | Episodic | Dynamic | Continuous |
| Refinery controller | Partially | Single | Stochastic | Sequential | Dynamic | Continuous |
| Interactive English tutor | Partially | Multi | Stochastic | Sequential | Dynamic | Discrete |

**Figure 2.6** Examples of task environments and their characteristics.

# Structure of Agents

- The job of AI is to design an agent program that implements the **agent function**.
- **Agent program** is an implementation of an agent function.
- An **Agent function** is a map from the percept sequence(history of all that an agent has perceived till date) to an action. **a = F(p)**

- **Agent = architecture + program**
- **Architecture:** A device with sensors and actuators (e.g., A robotic car, a camera, a PC)

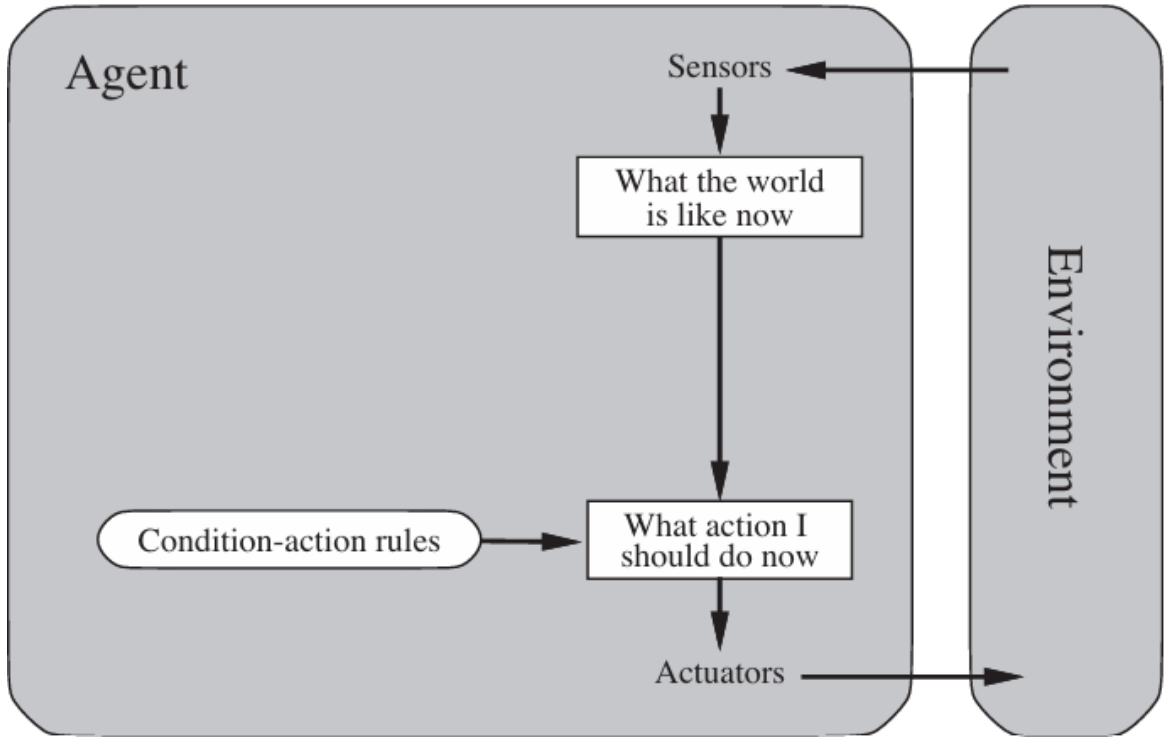
# Types of agents

Agents can be grouped into four classes based on their degree of perceived intelligence and capability :

1. **Simple Reflex Agents** (select actions based solely on the current percept)
2. **Model-Based Reflex Agents** (maintain an internal state to handle partially observable environments)
3. **Goal-Based Agents** (make decisions to minimize the distance from a defined goal)
4. **Utility-Based Agents** (optimize actions to maximize satisfaction or utility)
5. **Learning Agents** (improve over time by learning from past experiences)
6. **Problem Solving Agents** (use algorithms and search strategies to find solutions to specific problems)

# 1. Simple reflex Agents

- Simple reflex agents ignore the rest of the percept history and act only on the basis of the **current percept.**
- The agent function is based on the **condition-action rule**.
- If the condition is true, then the action is taken, else not.
- This agent function only **succeeds** when the environment is **fully observable.**
- The Simple reflex agent does not consider any part of percepts history during their decision and action process.




Ex: Turning on AC if temp is greater than 45 degrees.

```
function SIMPLE-REFLEX-AGENT(percept) returns an action
  persistent: rules, a set of condition–action rules

  state ← INTERPRET-INPUT(percept)
  rule ← RULE-MATCH(state, rules)
  action ← rule.ACTION
  return action
```

**A simple reflex agent. It acts according to a rule whose condition matches the current state, as defined by the percept.**

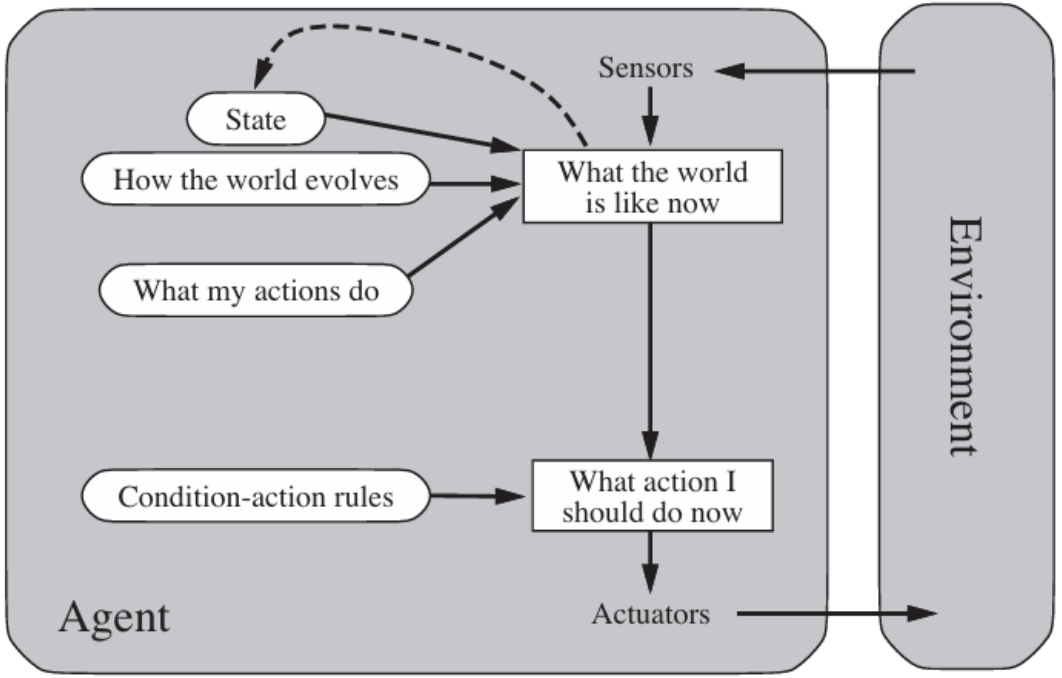
```
function REFLEX-VACUUM-AGENT([location,status]) returns an action

  if status = Dirty then return Suck
  else if location = A then return Right
  else if location = B then return Left
```

Percepts : Dirty, Clean

**Example**: A basic thermostat that turns the heating system on or off based solely on the current temperature reading, following a simple rule (e.g., if the temperature is below a certain threshold, turn on the heat).

# 2.Model-based reflex Agents

- The Model-based agent can work in a **partially observable environment**, and track the part of the world it can’t see now.
- **Internal State:** It is a representation of the current state based on percept history.
- **Model:** It is knowledge about "how things happen in the world," so it is called a Model-based agent.
- These agents have the model, ”which is knowledge of the world” and based on the model they perform actions.




**Updating the agent state requires information about:**

- How the world evolves
- How the agent’s action affects the world.

**function** MODEL-BASED-REFLEX-AGENT(*percept*) **returns** an action

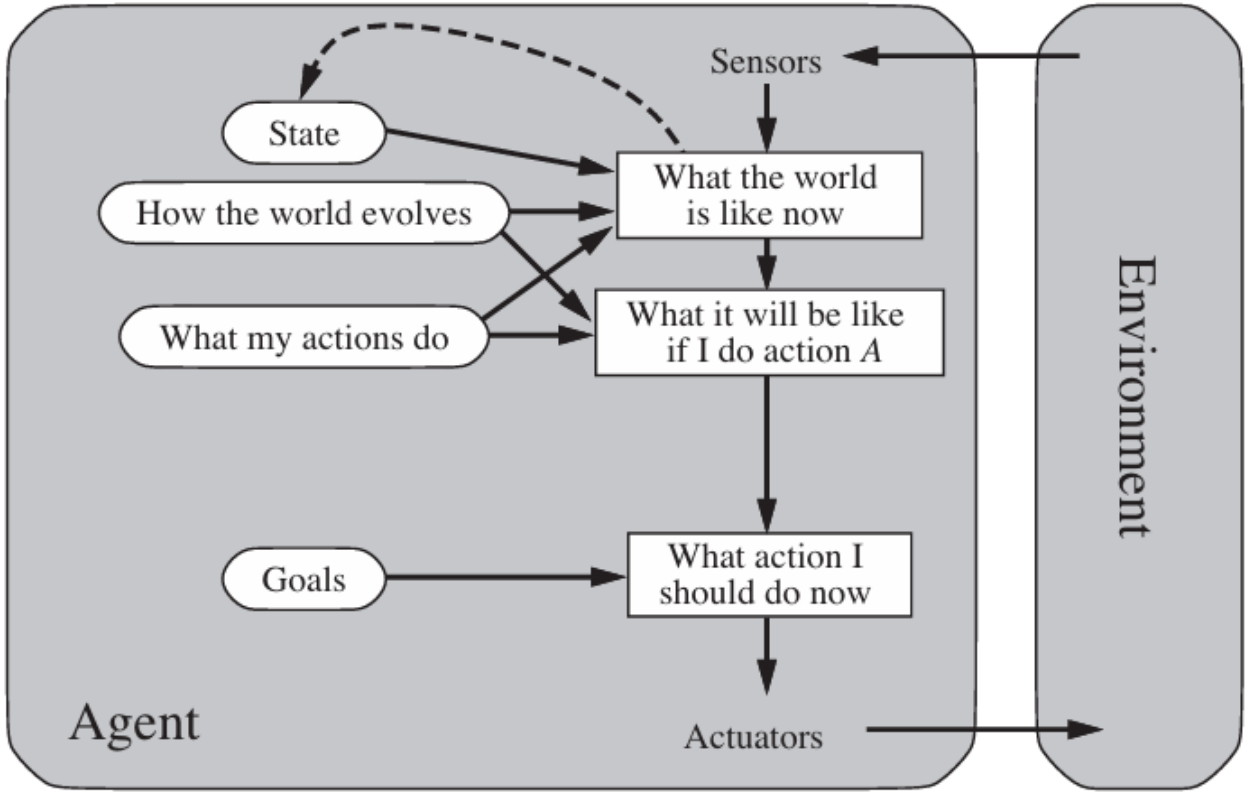
**persistent**: *state*, the agent's current conception of the world state
*model*, a description of how the next state depends on current state and action
*rules*, a set of condition–action rules
*action*, the most recent action, initially none

*state* ← UPDATE-STATE(*state*, *action*, *percept*, *model*)
*rule* ← RULE-MATCH(*state*, *rules*)
*action* ← *rule*.ACTION
**return** *action*

An automated vacuum cleaner that keeps track of the areas it has already cleaned (internal state) and adjusts its cleaning path based on previously mapped areas to ensure complete coverage of a room.

# 3.Goal-based Agents

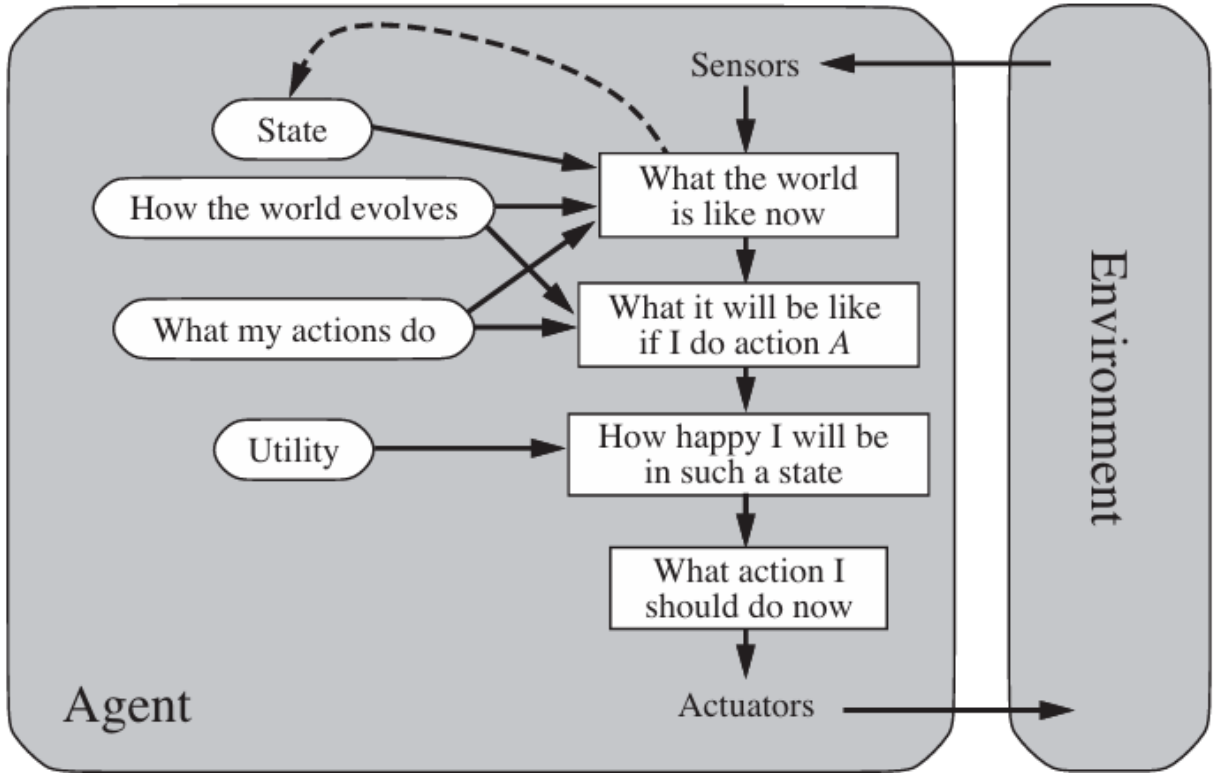
- A **goal-based agent** has an agenda.
- It operates based on a goal in front of it and makes decisions based on how best to reach that goal.
- A goal-based agent operates as a **search and planning** function, meaning it targets the goal ahead and finds the right action in order to reach it.
- It makes an agent proactive.
- These agents may have to consider a long sequence of possible actions before deciding whether the goal is achieved or not.
- **Example: Travel route to destination (Google Maps)**



# Goal Based agent(Ex: Gplus robot At Alibaba)

# 4.Utility-based Agents

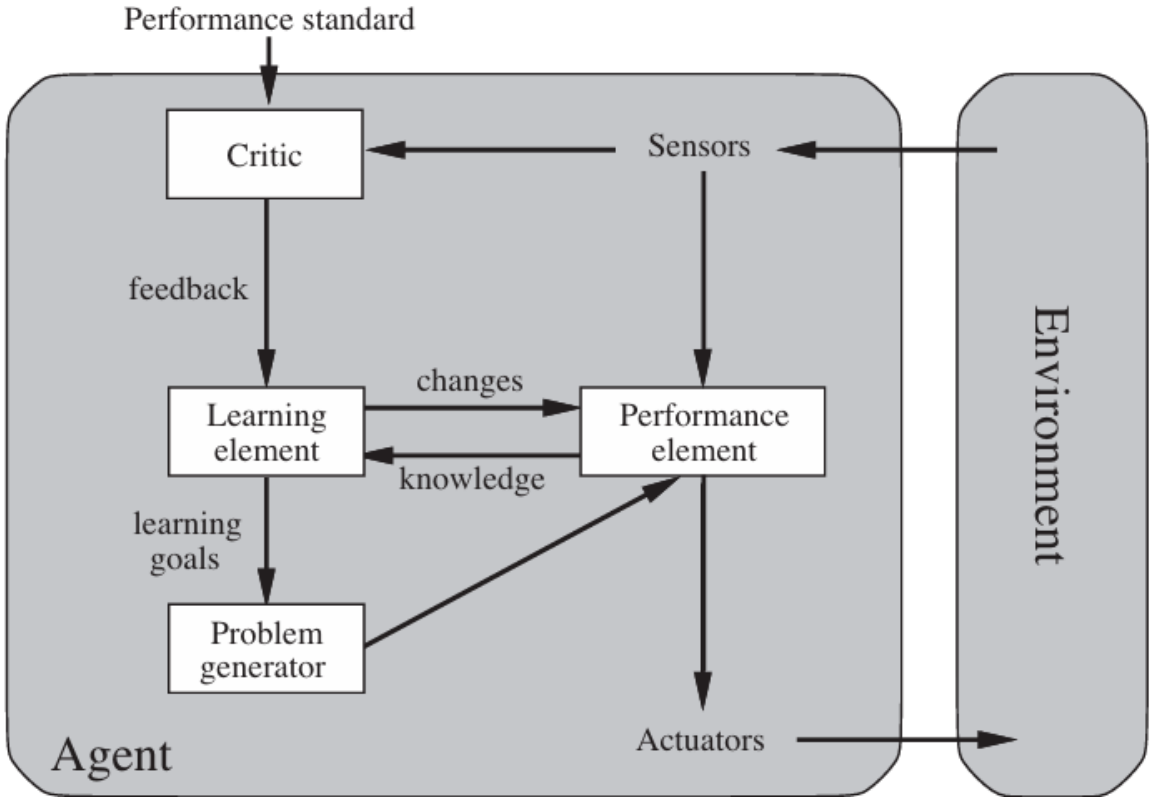
- A utility-based agent is an agent that acts based not only on what the goal is, but the best way to reach that goal.
- The Utility-based agent is useful when there are multiple possible alternatives, and an agent has to choose in order to perform the best action.
- The term utility can be used to describe how "happy" the agent is.
- The utility function maps each state to a real number to check how efficiently each action achieves the goals.




**Example: re-routing a GPS**

# 5.Learning Agents

- A learning agent in AI is the type of agent that **can learn from its past experiences** or it has learning capabilities.
- **Learning element**: It is responsible for making **improvements** by learning from the environment.
- **Critic:** The learning element takes **feedback** from critics which describes how well the agent is doing with respect to a fixed performance standard.
- **Performance element:** It is responsible for selecting external **action**
- **Problem Generator:** This component is responsible for **suggesting actions** that will lead to new and informative experiences.




**Ex: A recommendation system on streaming platforms (like Netflix)**