# Artificial Intelligence

By

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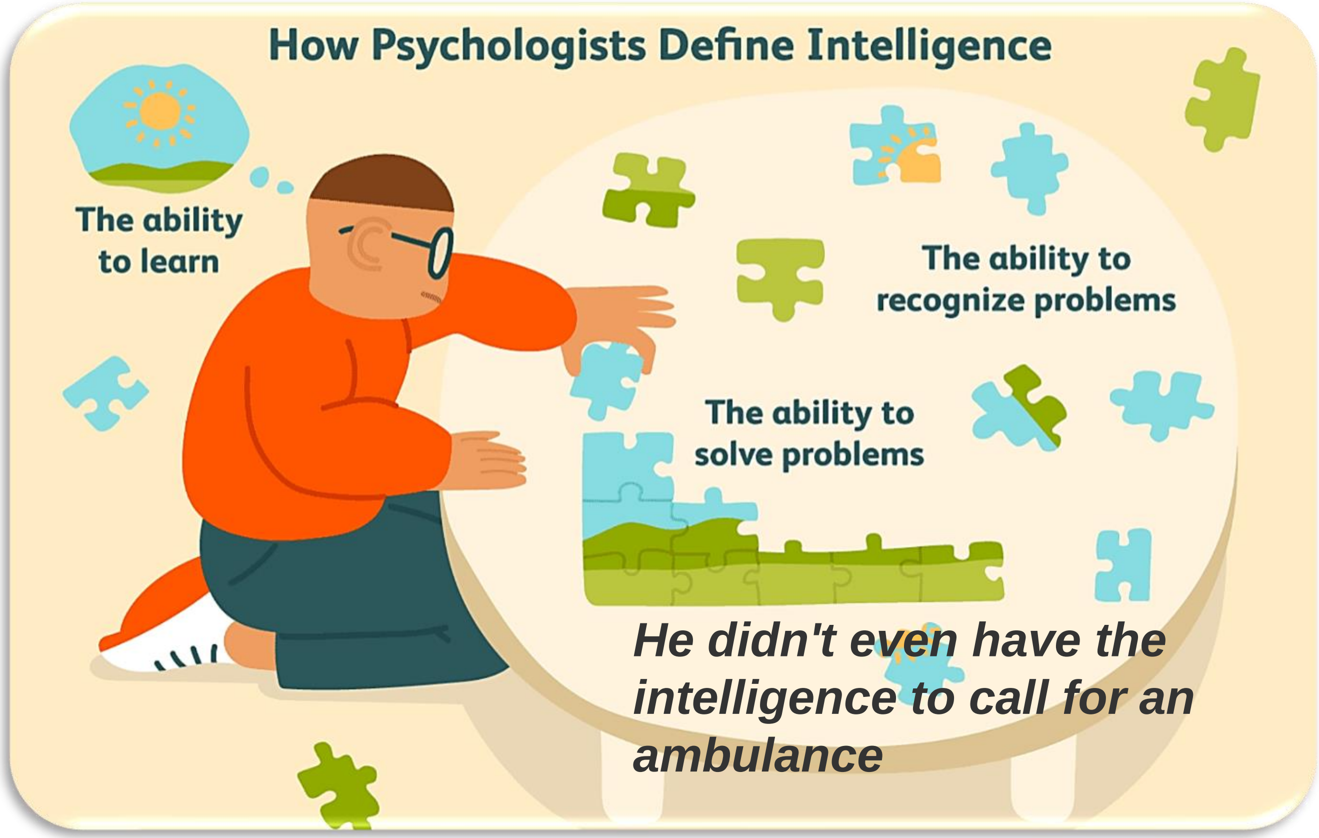
# What is Intelligence

## Oxford dictionary

- The ability to learn, understand and think in a "logical way" about things
- Intelligence : The ability to gain and apply knowledge and skills




**Intelligence refers to intellectual ability, which can be measured in terms of learning, understanding, reasoning, analyzing, remembering, problem-solving and fluent use of languages etc. It can be developed through study, contemplation, experience.**

# Logical Thinking

- **Logical thinking** is the process/skill of applying a chain of reasoning to **overcome a problem** and reach a conclusion/to a viable solution

- A good example of logical thinking in **action is the game of chess**. Playing chess involves working through a sequence of individual steps which take you closer to victory. Each step is an individual problem to be solved – within the framework of a larger game.

# Logical Thinking

- **So, what does logical thinking look like in practice?**

- **Logical thinking involves taking the relevant information and organizing it into a sequence**
- **Then thinking through it in steps**
- **While you can analyze and solve each step in and of itself, together they are part of the overall structure of the problem**
- **As you move through the steps, you move closer to solving the problem itself**

# Logical Thinking

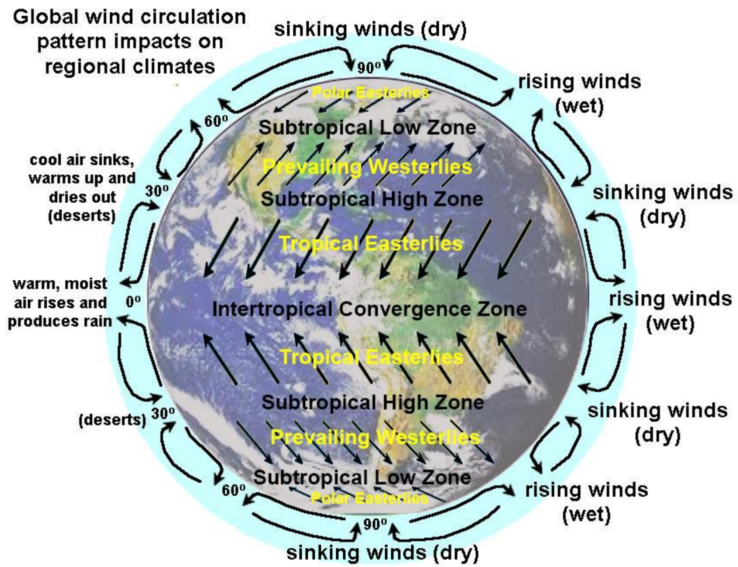
- **Maths:** Taking the information you are given and working out what to do with it as well as the steps needed to reach a solution.

  For example, to understand fractions you must first understand division. To understand simple algebra equations requires that you understand fractions.

- **Chemistry:** Setting up an experiment involves working out what chemicals and apparatus you need and what steps you need to take to reach a conclusion.
- **Computing:** The algorithms used by computers, smartphones and other electronic devices are in fact sets of logical instructions created by programmers.

# Logical Thinking

- **Geography:** **In field work, you will need to establish what observations are required to collect useful data, and how that data needs to be processed to reach valuable findings**




- **Sociology:** **Social scientists need to know what data collection methods and analysis techniques are required to reach meaningful conclusions about their research area**
- **History:** **for example, is full of mysteries to be solved by combining primary and secondary sources with an understanding of the wider context in which events happened.**

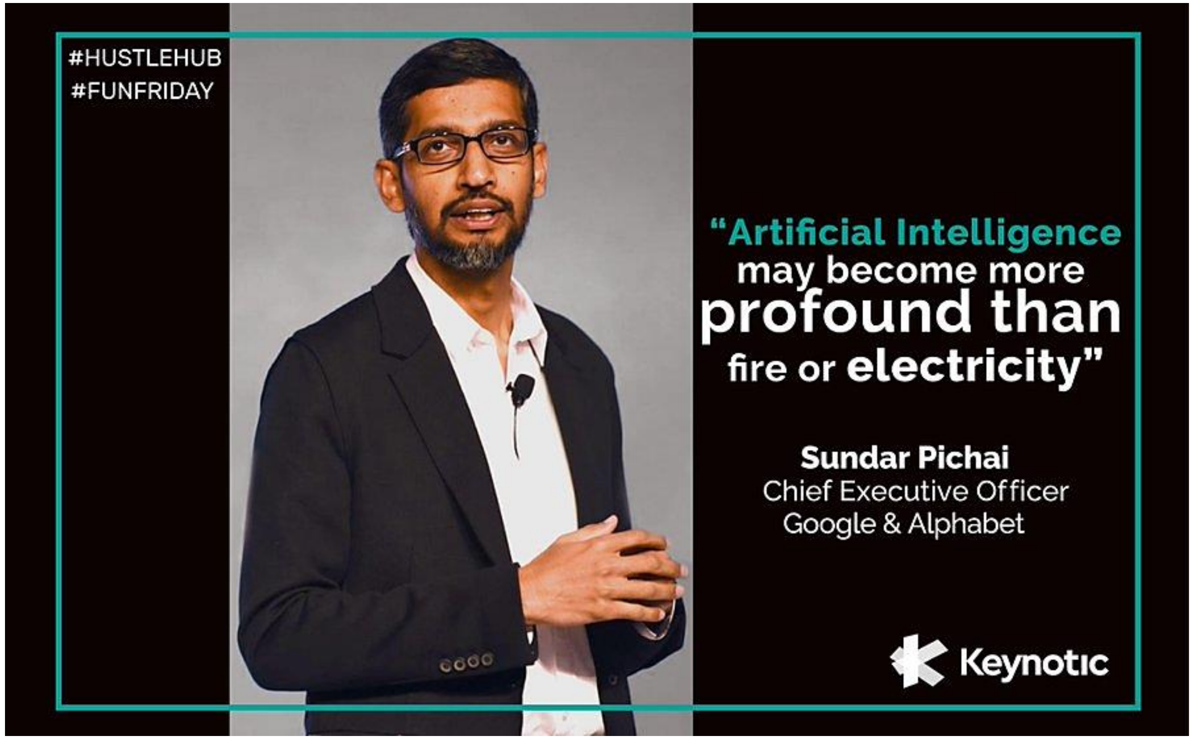
# What is Artificial Intelligence

- The field of artificial intelligence, or AI, is concerned with not just understanding but also building intelligent entities—machines that can compute how to act effectively and safely in a wide variety of novel situations

- Artificial intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think like humans and mimic their actions

**What Are The Two Things That Sundar Pichai Told Will Bring Revolution In Coming Times?**

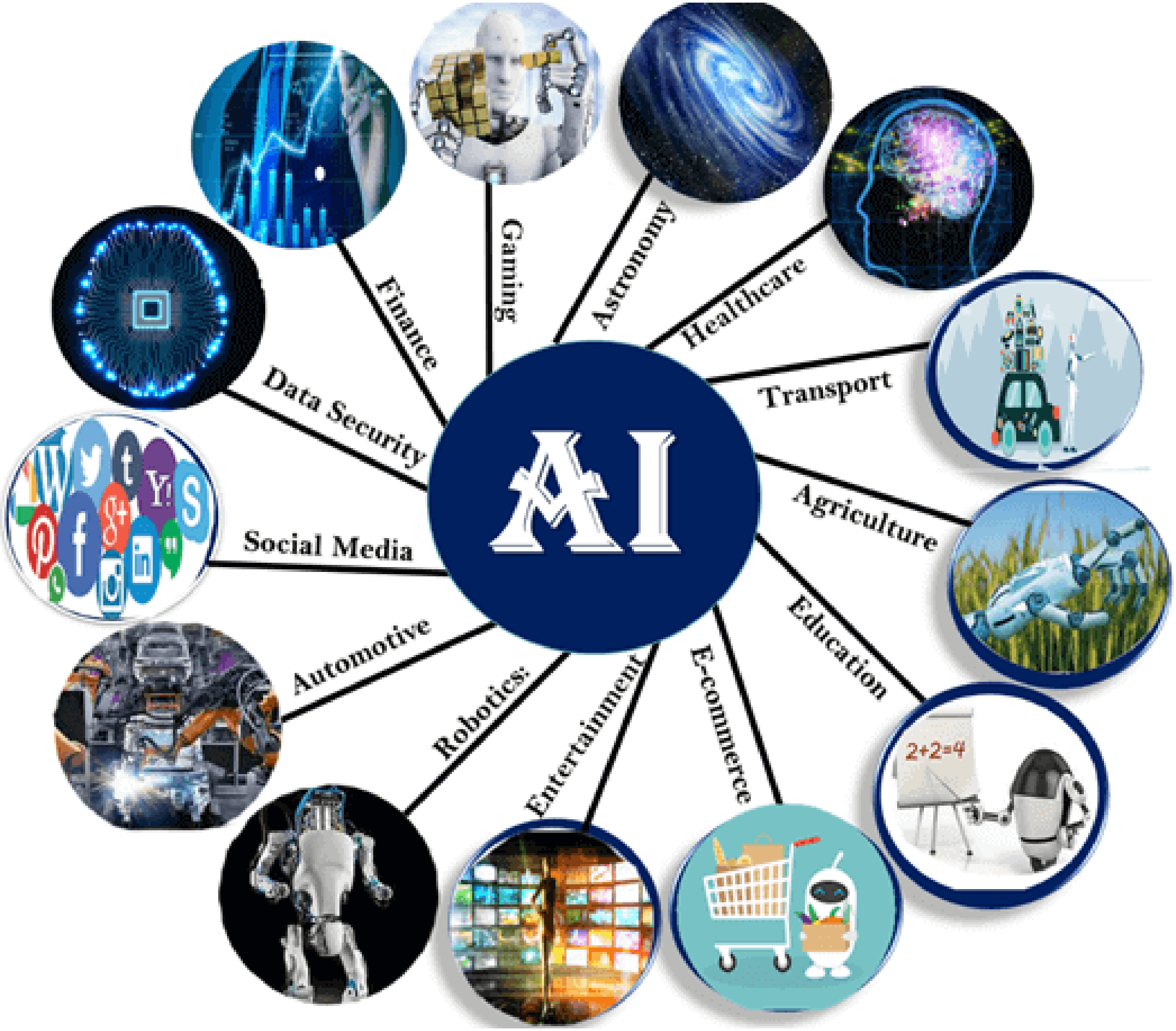
**“According to Google CEO Sundar Pichai, artificial intelligence and quantum computing will bring revolution in the coming 25 years.”**



# What is Artificial Intelligence

- Artificial Intelligence is a broad field i.e., different things to different people

- The main objective of AI is computers to do tasks that requires human Intelligence



# What is Artificial Intelligence

**People want to automate human Intelligence for the following reasons—**

(i) Understand human intelligence better

(ii) Smarter Programs

(iii) Useful techniques for solving difficult problems

**Artificial :** Made as a copy of something natural

**Intelligence :** The ability to gain and apply knowledge and skills

# Intelligence vs Artificial Intelligence

| | Intelligence | Artificial Intelligence |
|---|---|---|
| 1. | Natural | Programmed by human beings |
| 2. | Increases with experience, and also hereditary. | Nothing called hereditary but systems do learn from experience. |
| 3. | Highly refined and no electricity from outside is required to generate output. Rather knowledge is good for intelligence. | It is in computer system, and we need electrical energy to get output. Knowledge base is required to generate output. |
| 4. | No one is an expert. We can always get better solution from another human being. | Expert systems are made which have the capability of many individual person's experiences and ideas. |
| 5. | Intelligence Increases by supervised or unsupervised teaching. | We can increase AI's capabilities by other means apart from supervised and unsupervised teaching. |

- **Most work in AI involves studying the problems the world presents to intelligence rather than studying people or animals**
- **AI researchers are free to use methods that are not observed in people or that involve much more computing than people can do**

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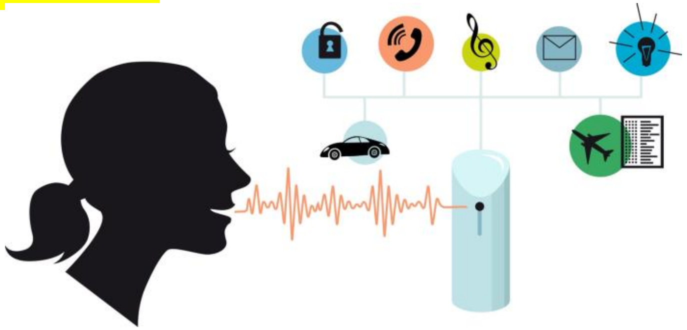
Lecture-2 History & concept of AI

# Tasks that requires Intelligence

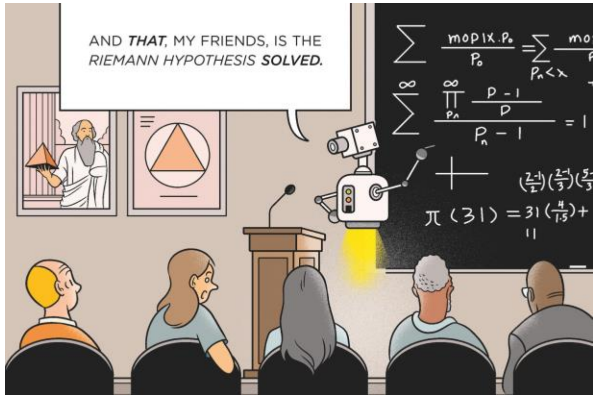
**Following is a list of tasks that require intelligence:**

1) Speech generation and understanding



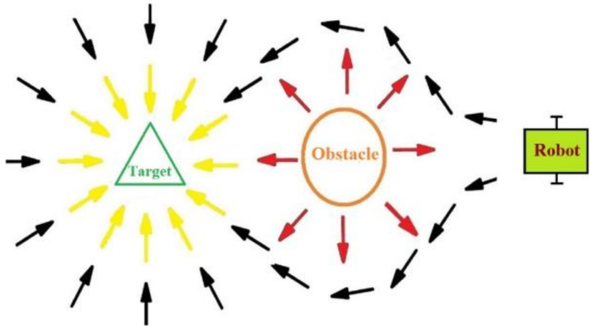
2) Pattern recognition


3) Mathematical theorem proving

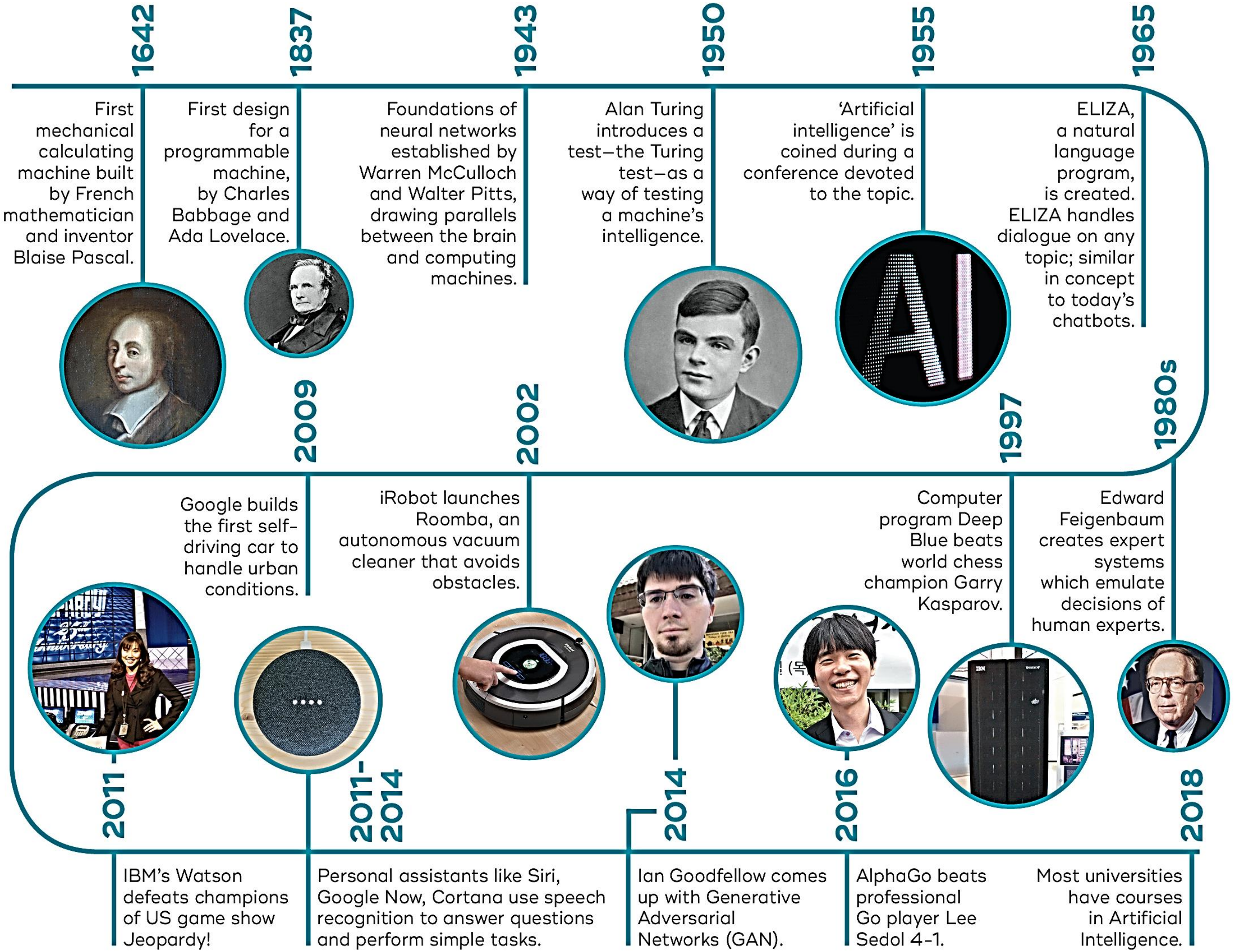



4) Reasoning

5) Motion in obstacle filled space



# Concept of AI/ Foundations of Artificial Intelligence History

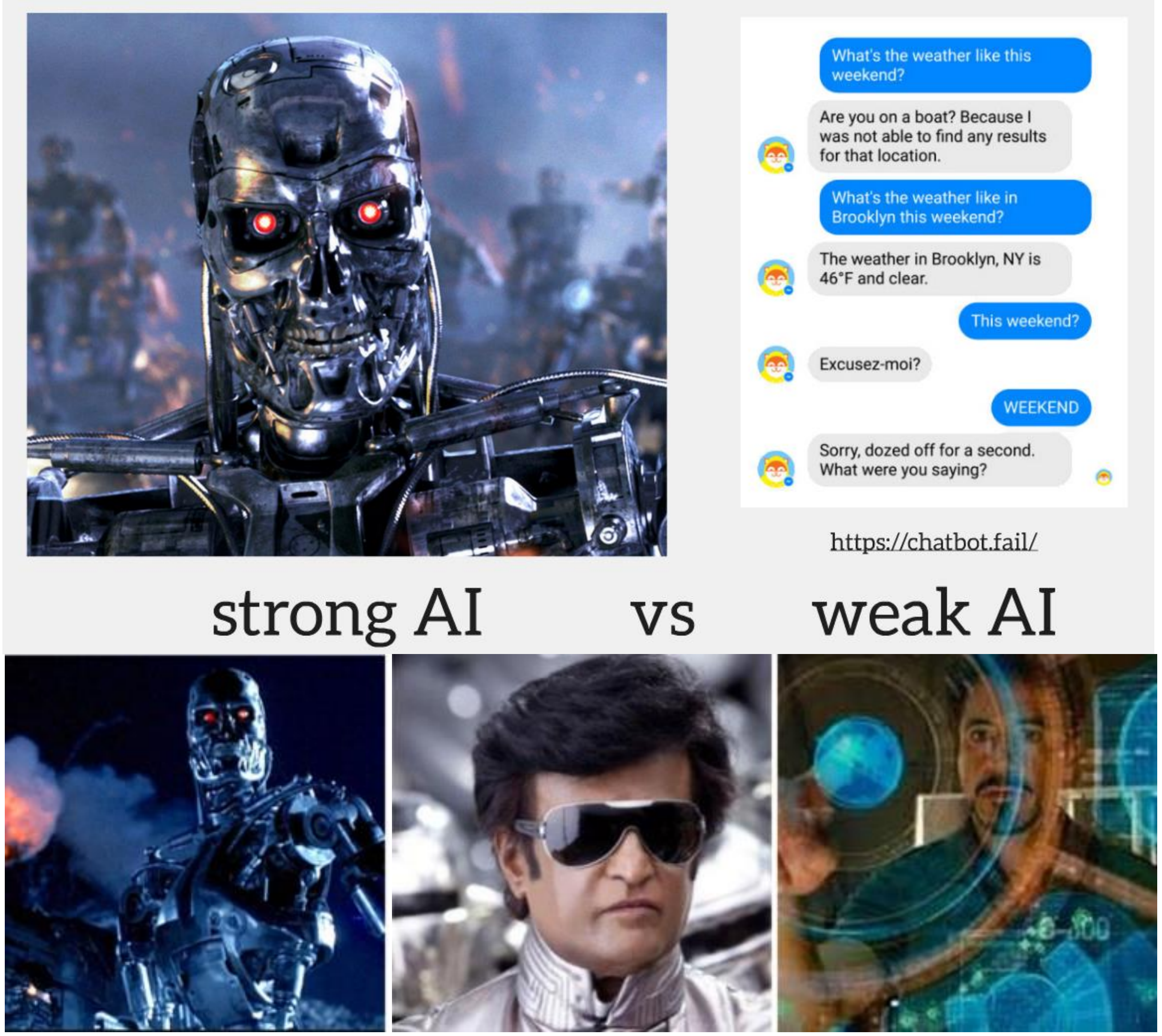


# Artificial Intelligence Classes

**The confusion about the word "intelligence", its ill definition and much broad sphere has led people to divide AI into two classes:**

## (i) Strong AI (“Doing")

## (ii) Weak AI ("Helping")




- **Weak AI is the hypothesis that a powerful enough computer could *simulate* any aspect of the human mind.**
- **Strong AI—in its original intended definition—is the hypothesis that "the brain is a digital computer, and the mind is a computer program". This view implies that if a programmer types the right program into a computer console, then that program would *emulate* (be equivalent to) a human mind.**

***Siri to Alexa, to Google Assistance, to Tesla’s self-driven cars***

# Artificial Intelligence Classes

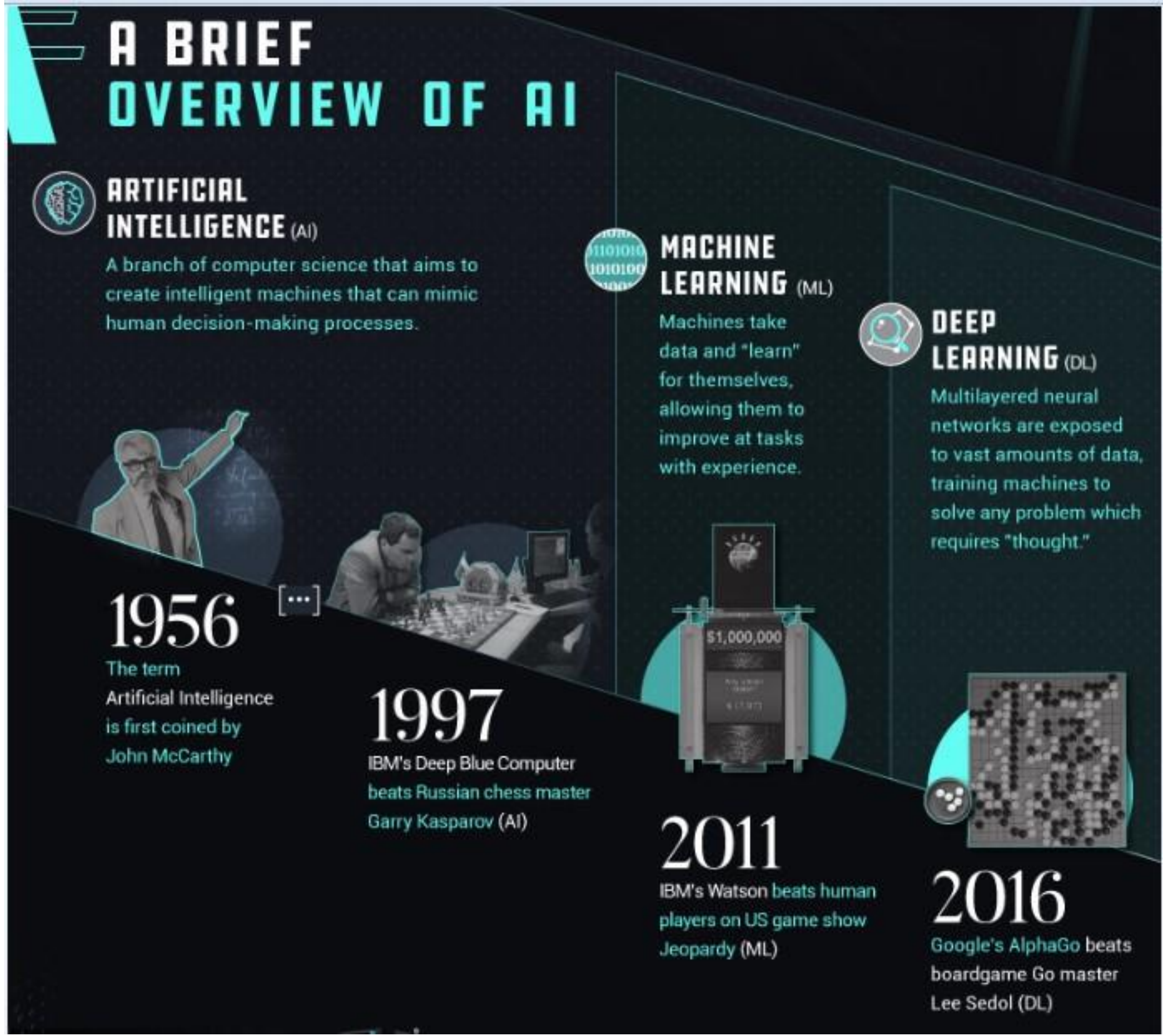
## What Are Simulators?

**A simulator mimics the basic behavior of a device.**

## What Are Emulators?

**An emulator duplicates the thing exactly as it exists in real life.**

**A simulator creates an environment that mimics the behavior and configurations of a real device. On the other hand, an emulator duplicates all the hardware and software features of a real device.**



# Artificial Intelligence Classes

**Strong AI** makes the bold claim that computers can be made to **think on a level at least equal to humans**. Strong AI research deals with the **creation of some form of computer-based artificial intelligence** that can truly reason and solve problems. People advocating strong AI believe that it will eventually lead to computers whose intelligence will greatly exceed than that of human beings. In strong AI the programs are themselves the explanations.

**Weak AI** simply states that some **"thinking-like" features** can be added to computers to make them more useful tool. Weak AI research deals with the creation of some form of computer-based artificial intelligence which can reason and solve problems in a limited domain. Hence, such a machine would act in some ways as if it was intelligent, but it would not possess true intelligence.
Some AI researchers are of the opinion that goal of AI should be to build machines that help people in their intellectual tasks rather than do these tasks. **"Helping" is called weak AI and "doing" is sometimes referred to as strong AI.**

# Definition of AI

- "The art of creating machines that perform functions that require intelligence when performed by people" (Kurzweil, 1990).

- "The branch of computer science that is concerned with the automation of intelligent behaviour". (Luger and Stublefield, 1993)

**Artificial Intelligence have the following properties**

| | |
|---|---|
| Systems that think like humans | Systems that think/rationally |
| Systems that act like humans | Systems that act rationally |

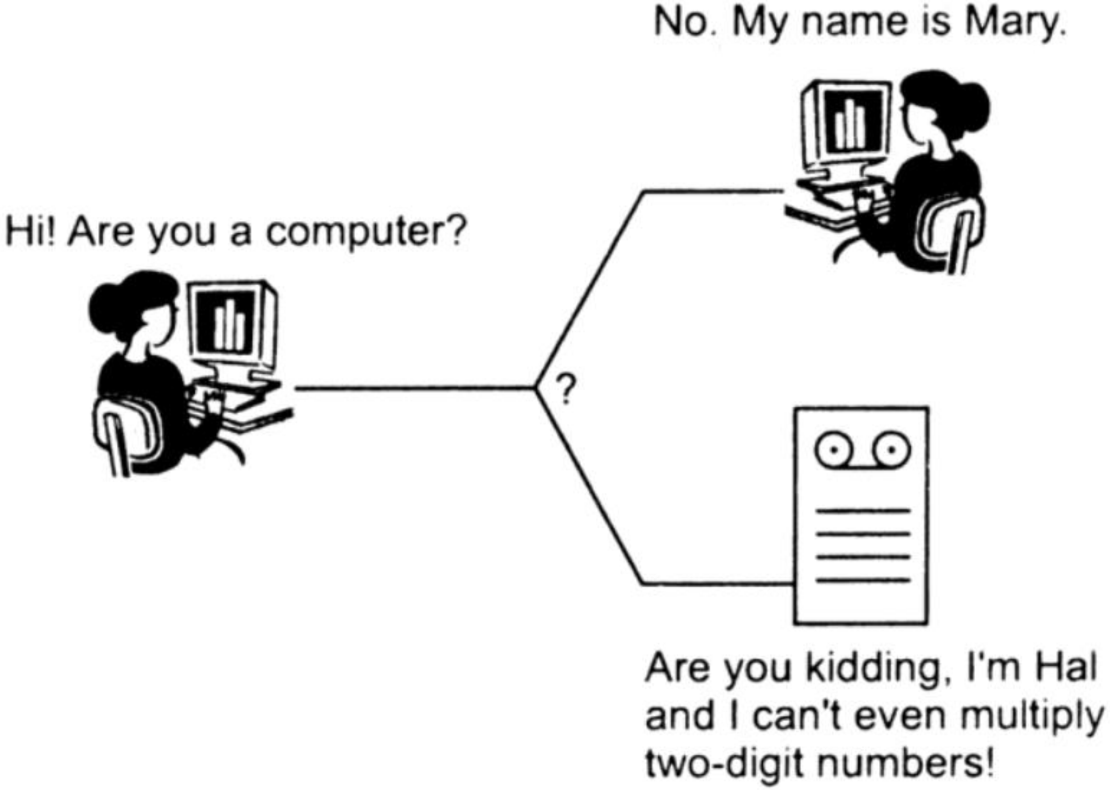
# Definition of AI

## (i) Acting Humanly : The Turing Test

• **If the response of a computer to an unrestricted textual natural-language conversation cannot be distinguished from that of a human being then it can be said to be intelligent.**

**Alan Mathison Turing**

**English** mathematician, computer scientist, logician, cryptanalyst, philosopher, and theoretical biologist.



# Definition of AI

**(ii) Thinking Humanly : Cognitive Modelling**

**• Method must not just exhibit behaviour sufficient to fool a human judge but must do it in a way demonstrably analogous to human congnition.**

**• Requires detailed matching of computer behaviour and timing to detailed measurements of human subjects gathered in psychological experiments.**

**• Cognitive Science : Inter-dislplinary field (AI, psychology, linguistics, philosophy, anthropology) that tries to form computational theories of human cognition.**

**(iii) Thinking Rationally : Laws of Thought**

**• Formalize "correct" reasoning using a mathematical model (e.g. of, deductive reasoning).**

**• Logicist Program Encode knowledge in formal logical statements and use mathematical deduction for performing reasoning**

**Problems:**
**Formalizing common sense knowledge is difficult.**
**General deductive inference is computationally intractable.**

# Definition of AI

(iv) Acting Rationally : Rational Agents

An agent is an entity that perceives its environment and is able to execute actions to change it.

- Agents have inherent goals that they want to achieve (e.g. survive, reproduce).
- A rational agent acts in a way to maximize the achievement of its goals.
- True maximization of goals requires omniscience and unlimited computational abilities.
- Limited rationality involved maximizing goals within the computational and other resources available

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# Concept of AI/ Foundations of Artificial Intelligence History

- **Disciplines that have contributed ideas, viewpoints and techniques to AI are many and can be considered to be the foundations of AI.**

- **They are philosophy, mathematics, economics, neuroscience, psychology, engineering (electrical, mechanical, computer and control), cognitive science and linguistics.**

- **Philosophers of 400 B.C. made AI conceivable by considering the ideas that the mind is in some ways like a machine. It operates on knowledge encoded in some internal language and that thought can be used to choose what action is to be taken.**

- **Mathematicians provided the tools to manipulate statements of logical certainty as well as uncertain, probabilistic statements. They also set the groundwork for understanding computation and reasoning about algorithms.**

- **Economists formalized the problem of making decisions that maximize the expected outcome to the decision-maker.**

- **Psychologists adopted the idea that humans and animals can be considered information-processing machines**
- **Linguists showed that language use fits into this model.**

- **Computer engineers provided the artifacts that make AI applications possible.**

# Concept of AI/ Foundations of Artificial Intelligence History

- **The great advances in speed and memory of the computer have made AI programs to be run**
- **Control theory has made possible the designing of devices that act optimally on the basis of feedback from the environment**
- **While knowledge of the history of AI is not essential to understand the subject**
- **We study it to interpret current developments**

# Concept of AI/ Foundations of Artificial Intelligence History

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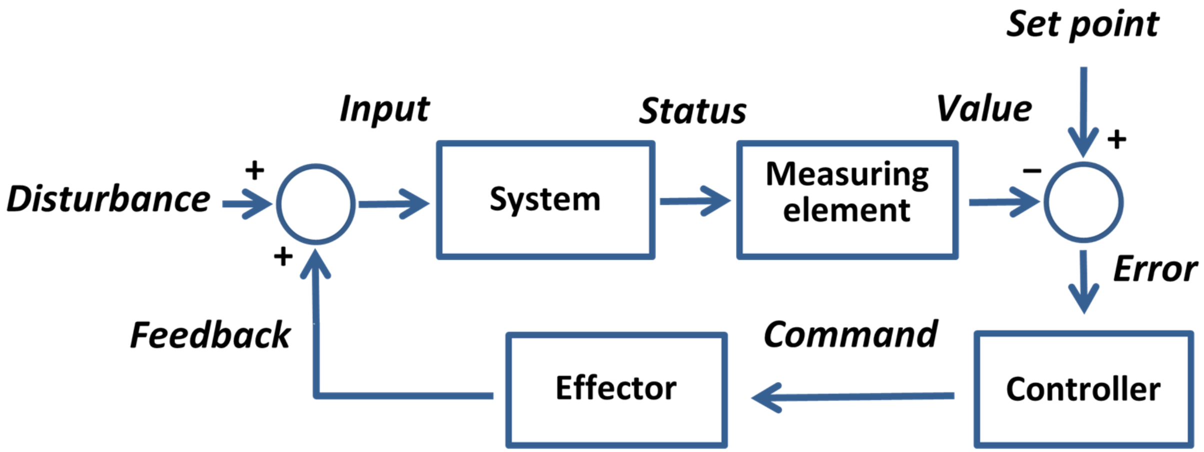


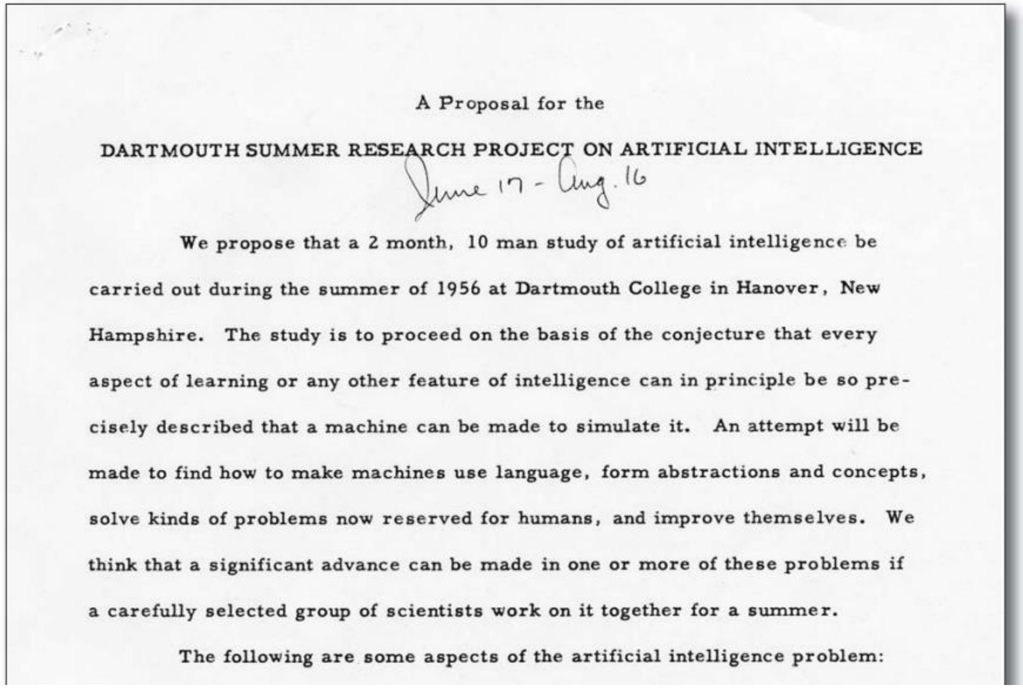

- While knowledge of the history of AI is not essential to understand the subject.
- We study it to interpret current developments.

# History of AI

- Our approach here will be to concentrate on a very small number of people, events and ideas.
- The important people associated with AI are Alen Turing, Warren McCulloch, Marvin Minsky, Allen Newell, Herbert Simon, John McCarthy etc.
- The most important event in the history of AI is the Dartmouth college summer workshop in June 1956 which is considered to be the official birth date of AI.
- However, we ignore many people, ideas and events that are also important and focus on only three things.
- The Dartmouth conference and Chinese room are discussed in brief whereas the 'Turing-test' will be discussed in detail

# History of AI

**(i) The Dartmouth Conference.** **In the summer of 1956 a two-month workshop was organized at Dartmouth (USA). The attendance list at this workshop read like a present-day who's who in the field—John McCarthy (creator of LISP), Marvin Minsky (leading AI researcher). Claude Shannon (Nobel prize winner) along-with seven other people attended this workshop. This workshop did not lead to any new break through but it did introduce all the major figures (and in other way many disciplines) to each other. The new name for the field "Artificial Intelligence" was thus coined.**



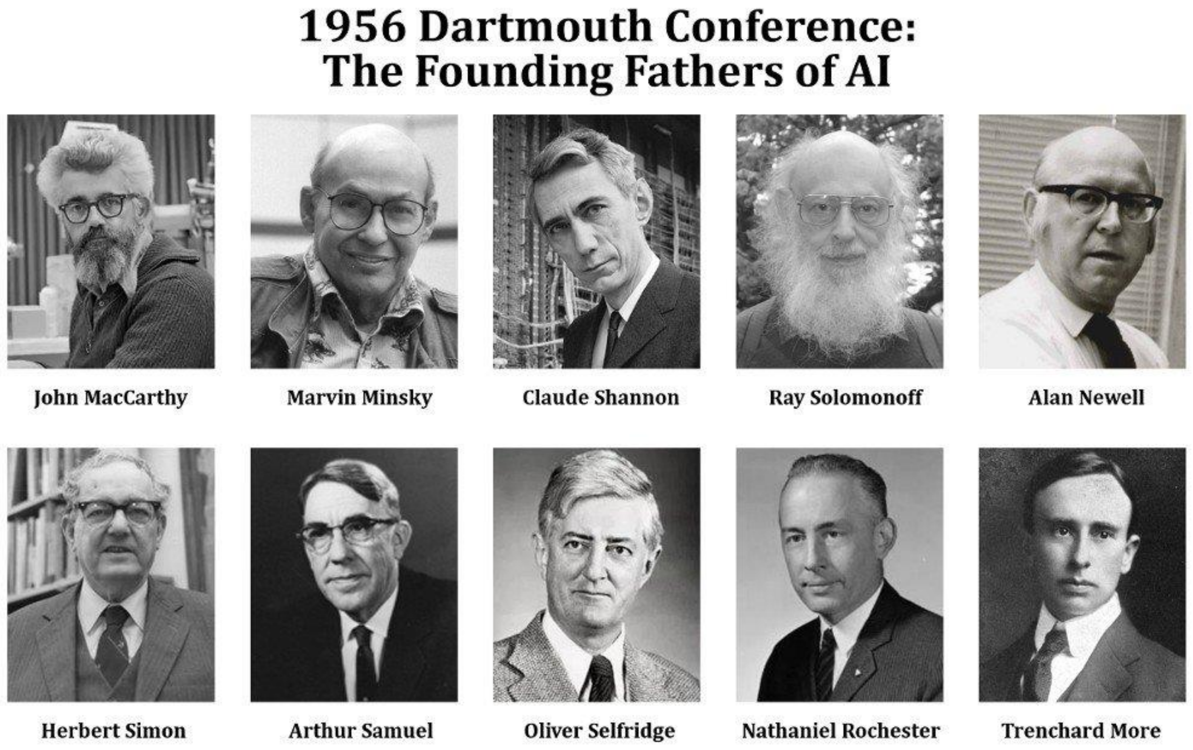
A Proposal for the

DARTMOUTH SUMMER RESEARCH PROJECT ON ARTIFICIAL INTELLIGENCE

June 17 - Aug. 16

We propose that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer.

The following are some aspects of the artificial intelligence problem:



# History of AI

**(ii) Turing Test:** This test provides an answer to the question, **"Can Machines Think"** in operational language

- The British mathematician **Alan Turing** is one of the founders of computer science and the **father Of artificial intelligence**
- More than 50 years ago he predicted **the advent of "thinking machines"**
- **In his times computers were slow.**
- Turing left a benchmark test for an intelligent computer; **it must fool a person into thinking the computer as human**

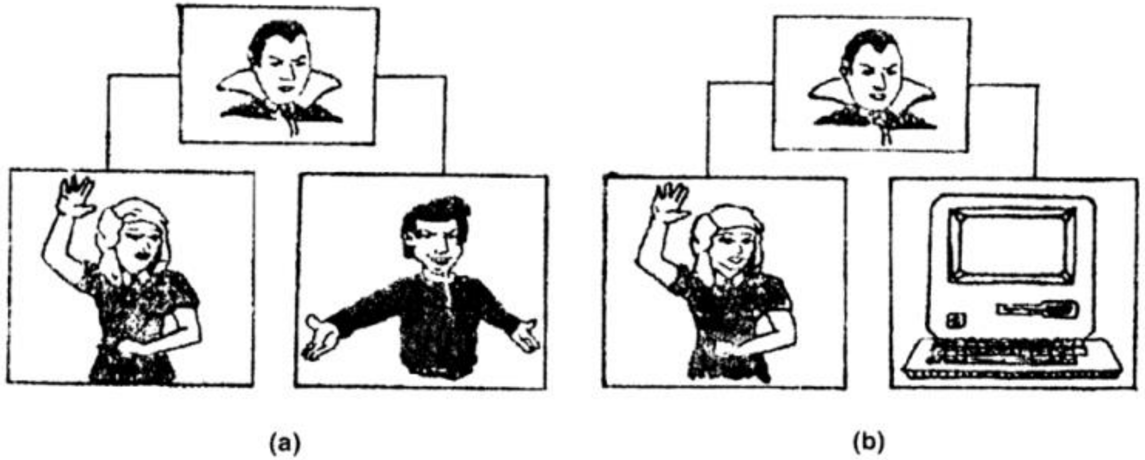
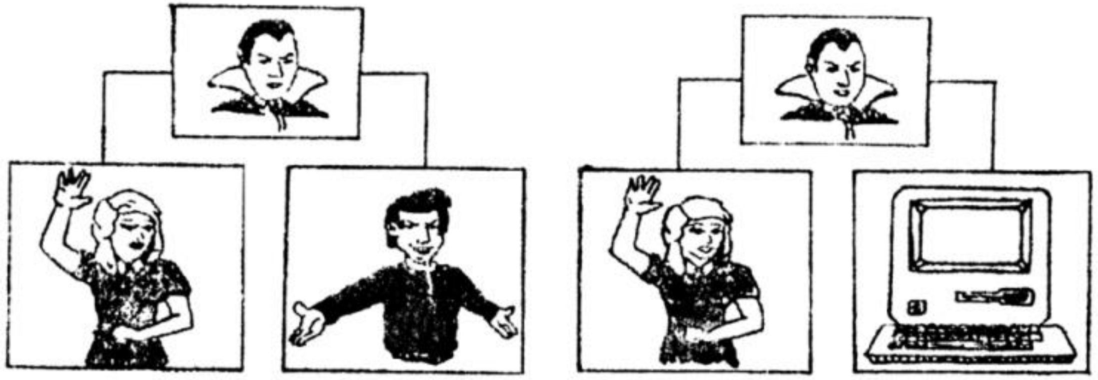



Fig. (3) Pictorial representation of Turing test.

# History of AI

**(ii) Turing Test** This test provides an answer to the question, 'Can Machines Think" in operational language.

- TURING TEST, was performed in two phases.
- In the first phase (fig, (3a)) the interrogator, isolates himself from the man and woman.
  Same questions are asked to both—man and woman through a neutral medium, say teletype writer and each party is isolated in separate room to eliminate the visual or audible clues.
- Questions asked included calculations of multiplication of big numbers and also some questions on lyrics and English literature.
- In the second phase (fig, (3b)) the man replaced by a computer without the knowledge of the interrogator. The interrogator cannot distinguish between man, woman or machine, rather he knows them as A and B.



(a) (b)

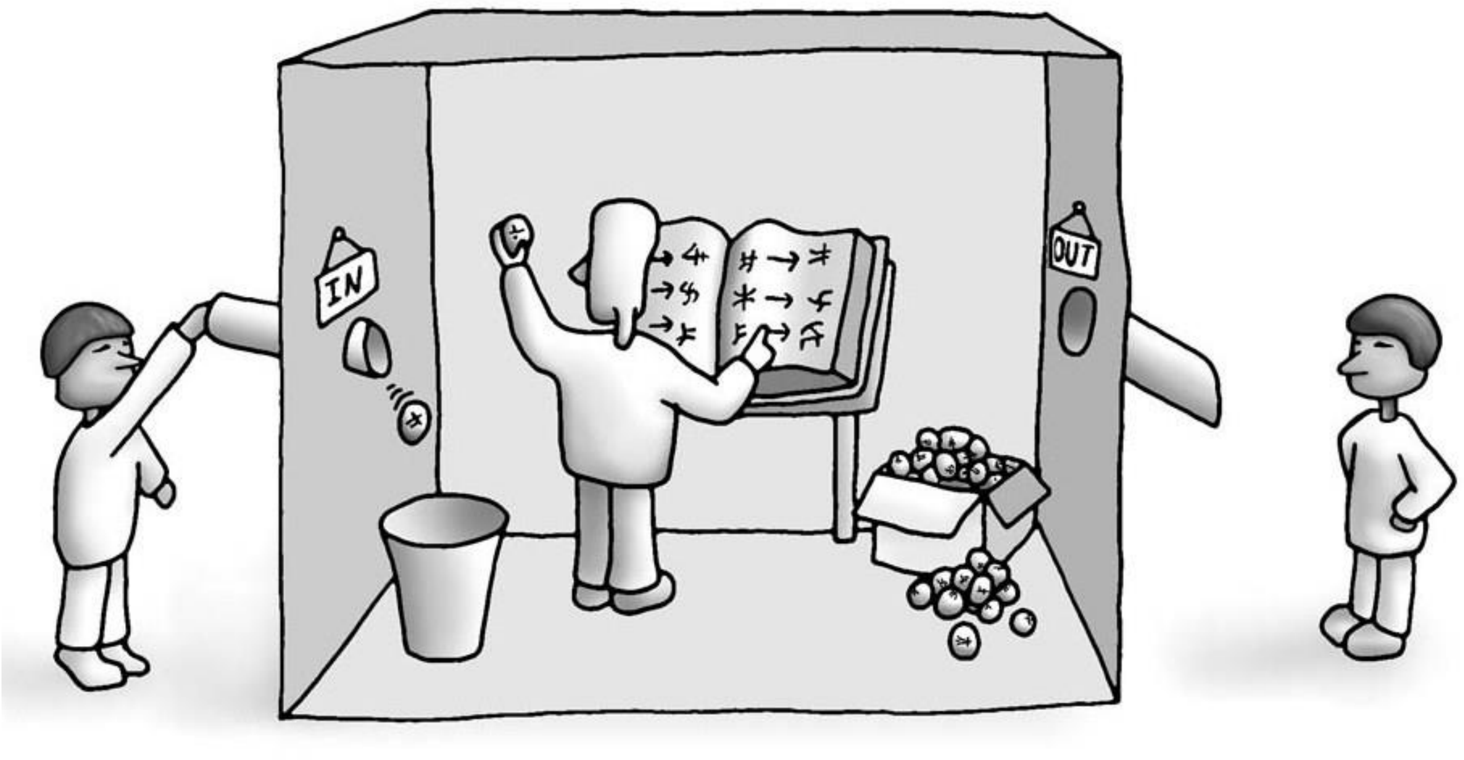
Fig. (3) Pictorial representation of Turing test.

# History of AI

**(iii) The Chinese Room :** **Searle** proposed the experiment of the Chinese Room to bring into the limelight the major flaw in the Turing test.

The Chinese Room is a thought experiment in which we are asked to imagine **a room containing a complete set of instructions** for manipulating and combining Chinese characters.

These instructions are written in English and can be implemented by a group of people who can follow the instructions, matching the characters on the basis of appearance.



# History of AI

Suppose a story is passed into the room, followed by a series of questions about the story in Chinese.

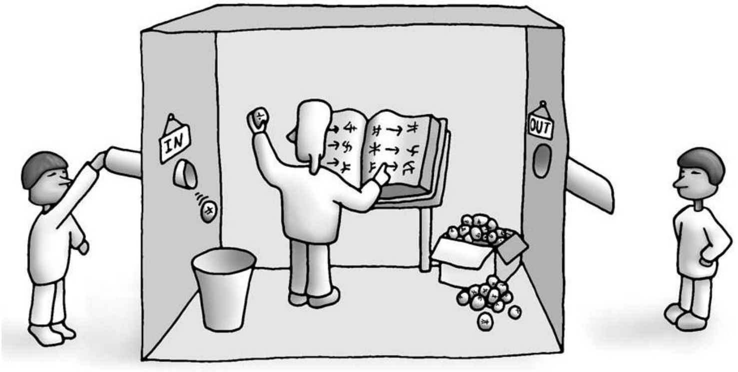
By referring to their rules, the people in the room are able to produce a third set of Chinese characters representing the answers.

In this way, Searle showed and argued that people could behave as if they are fluent in a foreign language while actually, they are unable to understand a word of it.

Hence, if a machine passes the **Turing test, it can not be assumed to be** intelligent as it only manipulates formal symbols but lacks understanding. As of today, Turing test is the ultimate test a machine must pass in order to be called as intelligent.

Every year **The Loebner prize is awarded to the program that comes closest to passing a version of the Turing-test.**

Today's chatbots, computer program which has a persona and a name, chats with you is incapable of dealing with changes in context or abstract ideas and succeeds only at momentarily tricking people only for pre-programmed answers.



### 1.4.1 What computers do better than people?

The computers may perform these so called 'human' activities even more efficiently than the most of human beings. They are for example :

(a) *Numerical Computation* : Computers are without doubt faster and more accurate than humans in numerical computations. Also, the chances of error is almost zero in case of computers.

(b) *Information Storage* : Computers can store huge amounts of information whereas in human beings only a certain amount of knowledge can be stored.

(c) *Repetitive Operations* : It is well known that the computers do not get bored and commit mistakes as fatigue sets in even when they repeat the same process every day. If a computer is used to print out one thousand copies of a document, all will

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**Lecture-4** **Current status & Scope of Artificial Intelligence**

# Current Status of Artificial Intelligence

## The State of the Art

Stanford University's One Hundred Year Study on AI (also known as AI100) convenes panels of experts to provide reports on the state of the art in AI. Their 2016 report (Stone et al., 2016; Grosz and Stone, 2018) concludes that "Substantial increases in the future uses of AI applications, including more self-driving cars, healthcare diagnostics and targeted treatment, and physical assistance for elder care can be expected" and that "Society is now at a crucial juncture in determining how to deploy AI-based technologies in ways that promote rather than hinder democratic values such as freedom, equality, and transparency." AI100 also produces an AI Index at aiindex.org to help track progress. Some highlights from the 2018 and 2019 reports (comparing to a year 2000 baseline unless otherwise stated):

# Current Status of Artificial Intelligence

- **Publications:** AI papers increased 20-fold between 2010 and 2019 to about 20,000 a year. The most popular category was machine learning. (Machine learning papers in arXiv.org doubled every year from 2009 to 2017.) Computer vision and natural language processing were the next most popular.
- **Sentiment:** About 70% of news articles on AI are neutral, but articles with positive tone increased from 12% in 2016 to 30% in 2018. The most common issues are ethical: data privacy and algorithm bias.
- **Students:** Course enrollment increased 5-fold in the U.S. and 16-fold internationally from a 2010 baseline. AI is the most popular specialization in Computer Science.
- **Diversity:** AI Professors worldwide are about 80% male, 20% female. Similar numbers hold for Ph.D. students and industry hires.
- **Conferences:** Attendance at NeurIPS increased 800% since 2012 to 13,500 attendees. Other conferences are seeing annual growth of about 30%.
- **Industry:** AI startups in the U.S. increased 20-fold to over 800.
- **Internationalization:** China publishes more papers per year than the U.S. and about as many as all of Europe. However, in citation-weighted impact, U.S. authors are 50% ahead of Chinese authors.

# Current Status of Artificial Intelligence

- **Vision:** Error rates for object detection (as achieved in LSVRC, the Large-Scale Visual Recognition Challenge) improved from 28% in 2010 to 2% in 2017, exceeding human performance. Accuracy on open-ended visual question answering (VQA) improved from 55% to 68% since 2015, but lags behind human performance at 83%.
- **Speed:** Training time for the image recognition task dropped by a factor of 100 in just the past two years. The amount of computing power used in top AI applications is doubling every 3.4 months.
- **Language:** Accuracy on question answering, as measured by F1 score on the Stanford Question Answering Dataset (SQUAD), increased from 60 to 95 from 2015 to 2019; on the SQUAD 2 variant, progress was faster, going from 62 to 90 in just one year. Both scores exceed human-level performance.
- **Human benchmarks:** By 2019, AI systems had reportedly met or exceeded human level performance in chess, Go, poker, Pac-Man, Jeopardy!, ImageNet object detection, speech recognition in a limited domain, Chinese-to-English translation in a restricted domain, Quake III, Dota 2, StarCraft II, various Atari games, skin cancer detection, prostate cancer detection, protein folding, and diabetic retinopathy diagnosis.

# Scope of AI

## What can AI do today?

**Perhaps not as much as some of the more optimistic media articles might lead one to believe, but still a great deal.**

**Robotic vehicles:** The history of robotic vehicles stretches back to radio-controlled cars of the 1920s, but the first demonstrations of autonomous road driving without special guides occurred in the 1980s (Kanade et al., 1986; Dickmanns and Zapp, 1987). After successful demonstrations of driving on dirt roads in the 132-mile DARPA Grand Challenge in 2005 and on streets with traffic in the 2007 Urban Challenge, the race to develop self-driving cars began in earnest. In 2018, Waymo test vehicles passed the landmark of 10 million miles driven on public roads without a serious accident, with the human driver stepping in to take over control only once every 6,000 miles. Soon after, the company began offering a commercial robotic taxi service.

In the air, autonomous fixed-wing drones have been providing cross-country blood deliveries in Rwanda since 2016. Quadcopters perform remarkable aerobatic maneuvers, explore buildings while constructing 3-D maps, and self-assemble into autonomous formations.

# Scope of AI

**Legged locomotion:** BigDog, a quadruped robot by Raibert et al. (2008), upended our notions of how robots move—no longer the slow, stiff-legged, side-to-side gait of Hollywood movie robots, but something closely resembling an animal and able to recover when shoved or when slipping on an icy puddle. Atlas, a humanoid robot, not only walks on uneven terrain but jumps onto boxes and does backflips (Ackerman and Guizzo, 2016).

# Scope of AI

**Autonomous planning and scheduling:** A hundred million miles from Earth, NASA's Remote Agent program became the first on-board autonomous planning program to control the scheduling of operations for a spacecraft (Jonsson et al., 2000). Remote Agent generated plans from high-level goals specified from the ground and monitored the execution of those plans—detecting, diagnosing, and recovering from problems as they occurred. Today, the planning toolkit (Barreiro et al., 2012) is used for daily operations of NASA's Mars rovers and the system (Winternitz, 2017) allows autonomous navigation in deep pace, beyond the global GPS system.

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, transport capacities, port and airfield capacities, and conflict resolution among all parameters. The Defense Advanced Research Project Agency (DARPA) stated that this single application more than paid back DARPA's 30-year investment in AI.

Every day, ride hailing companies such as Uber and mapping services such as Google Maps provide driving directions for hundreds of millions of users, quickly plotting an optimal route taking into account current and predicted future traffic conditions

# Scope of AI

**Machine translation:** **Online machine translation systems now enable the reading of documents in over 100 languages,** including the native languages of over 99% of humans, and render hundreds of billions of words per day for hundreds of millions of users. While not perfect, they are generally adequate for understanding. For closely related languages with a great deal of training data (such as French and English) translations within a narrow domain are close to the level of a human (Wu et al., 2016b).

# Scope of AI

**Speech recognition:** In 2017, **Microsoft showed that its Conversational Speech Recognition System had reached a word error rate of 5.1%, matching human performance on the Switchboard task**, which involves transcribing telephone conversations (Xiong et al., 2017).

About a third of computer interaction worldwide is now done by voice rather than keyboard; **Skype provides real-time speech-to-speech translation** in ten languages. **Alexa, Siri, Cortana, and Google offer assistants that can answer questions** and carry out tasks for the user; for example the Google Duplex service uses speech recognition and speech synthesis to make restaurant reservations for users, carrying out a fluent conversation on their behalf.

# Scope of AI

**Recommendations:** Companies such as Amazon, Facebook, Netflix, Spotify, YouTube, Walmart, and others **use machine learning to recommend what you might like based on your past experiences** and those of others like you. The field of recommender systems has a long history (Resnick and Varian, 1997) but is changing rapidly due to new deep learning methods that analyze content (text, music, video) as well as history and metadata (van den Oord et al., 2014; Zhang et al., 2017). Spam filtering can also be considered a form of recommendation (or dis recommendation); current AI techniques filter out over 99.9% of spam, and email services can also recommend potential recipients, as well as possible response text.

# Scope of AI

**Game playing:** When Deep Blue defeated world chess champion Garry Kasparov in 1997, defenders of human supremacy placed their hopes on Go. Piet Hut, an astrophysicist and Go enthusiast, predicted that it would take "a hundred years before a computer beats humans at Go—maybe even longer." **But just 20 years later, ALPHAGO surpassed all human players (Silver et al., 2017). Ke Jie, the world champion, said, "Last year, it was still quite human-like when it played.** But this year, it became like a god of Go." ALPHAGO benefited from studying hundreds of thousands of past games by human Go players, and from the distilled knowledge of expert Go players that worked on the team. A followup program, ALPHAZERO, used no input from humans (except for the rules of the game), and was able to learn through self-play alone to defeat all opponents, human and machine, at Go, chess, and shogi (Silver et al., 2018). Meanwhile, human champions have been beaten by AI systems at games as diverse as Jeopardy! (Ferrucci et al., 2010), poker (Bowling et al., 2015; Moravˇc´ık et al., 2017; Brown and Sandholm, 2019), and the video games Dota 2 (Fernandez and Mahlmann, 2018), StarCraft II (Vinyals et al., 2019), and Quake III (Jaderberg et al., 2019).

# Scope of AI

**Image understanding:** Not content with exceeding human accuracy on the challenging ImageNet object recognition task, computer vision researchers have taken on the more difficult problem of image captioning. Some impressive examples include “A person riding a motorcycle on a dirt road,” “Two pizzas sitting on top of a stove top oven,” and “A group of young people playing a game of frisbee” (Vinyals et al., 2017b). Current systems are far from perfect, however: a “refrigerator filled with lots of food and drinks” turns out to be a no-parking sign partially obscured by lots of small stickers.

# Scope of AI

**Medicine:** AI algorithms now equal or exceed expert doctors at diagnosing many conditions, particularly when the diagnosis is based on images.

*Examples include Alzheimer's disease* (Ding et al., 2018), metastatic cancer (Liu et al., 2017; Esteva et al., 2017), ophthalmic disease (Gulshan et al., 2016), and skin diseases (Liu et al., 2019c). A systematic review and meta-analysis (Liu et al., 2019a) found that the performance of AI programs, on average, was equivalent to health care professionals. One current emphasis in medical AI is in facilitating human–machine partnerships. *For example*, the LYNA system achieves 99.6% overall accuracy in diagnosing metastatic breast cancer—better than an unaided human expert—but the combination does better still (Liu et al., 2018; Steiner et al., 2018). The widespread adoption of these techniques is now limited not by diagnostic accuracy but by the need to demonstrate improvement in clinical outcomes and to ensure transparency, lack of bias, and data privacy (Topol, 2019). In 2017, only two medical AI applications were approved by the FDA, but that increased to 12 in 2018, and continues to rise.

# Scope of AI

**Climate science:** A team of scientists won the 2018 Gordon Bell Prize for a deep learning model that discovers detailed information about extreme weather events that were previously buried in climate data. They used a supercomputer with specialized GPU hardware to exceed the exaop level ($10^{18}$ operations per second), the first machine learning program to do so (Kurth et al., 2018). Rolnick et al. (2019) present a 60-page catalog of ways in which machine learning can be used to tackle climate change.

# Artificial Intelligence

By

**Dr. Manoj Kumar**

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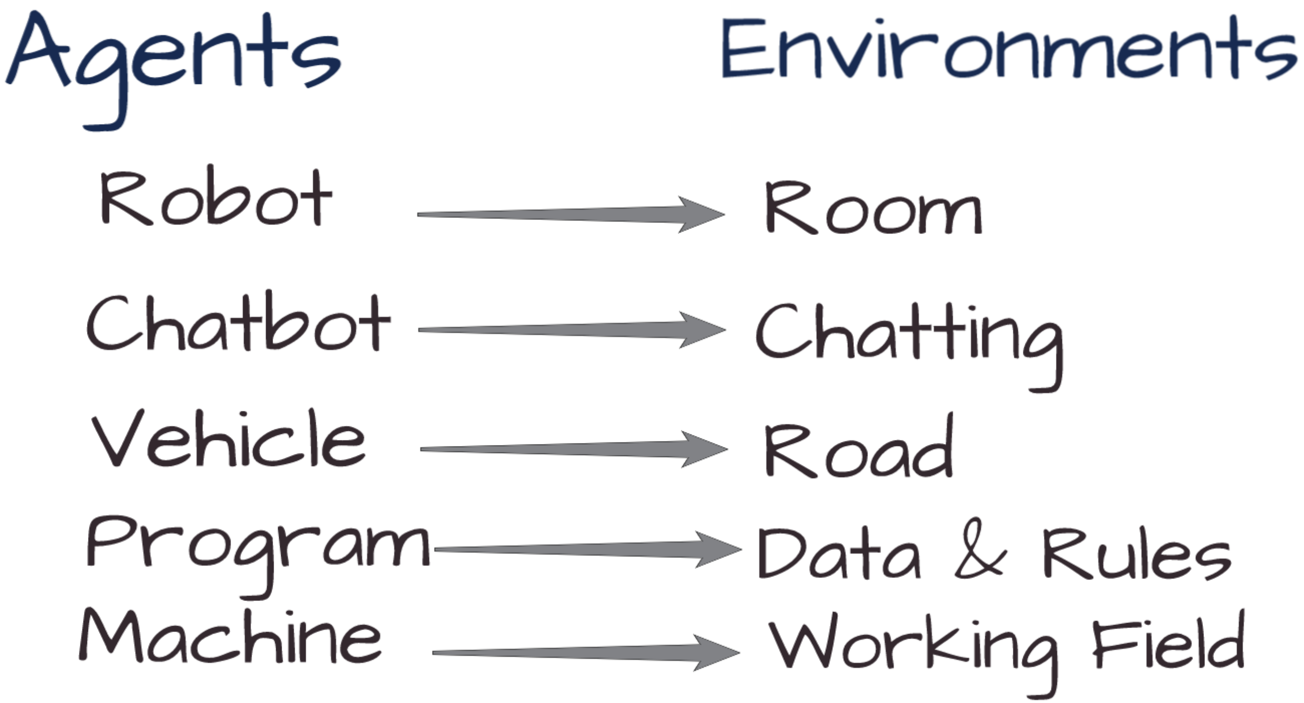
# Agents in AI

- Agent and Environment are two pillars in Artificial Intelligence, our aim is to build intellectual agents and work in an environment

- In simple terms, even starter or researcher can understand that and is defined Agent as game and Environment as ground



# Agents in AI

- The word "agent" is derived from the concept of agency which means employing someone to act on behalf of the user
- We know that authors have agents, professional athletes have agents, movie stars have agents and even you have agents
- This is because an agent is someone with expertise who is assigned to act on our behalf
- An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators

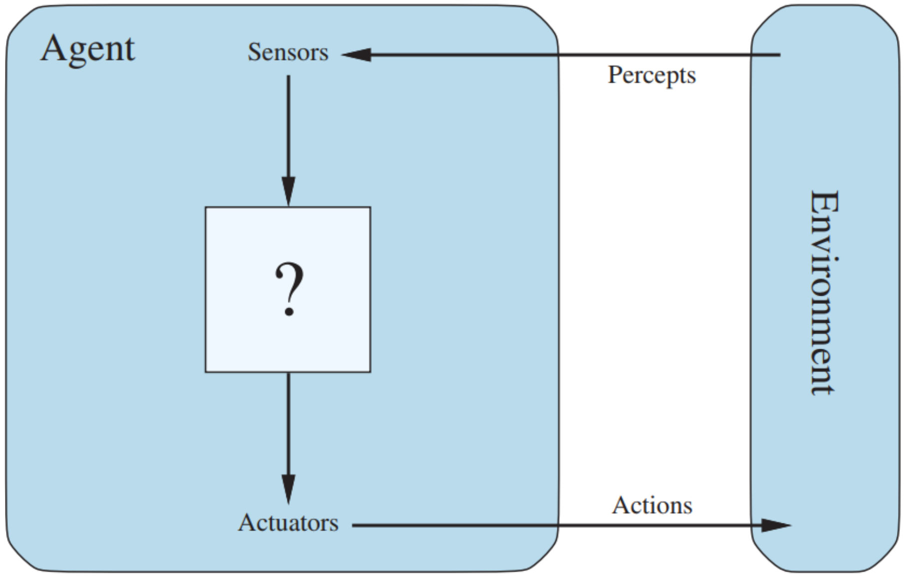
**Actuators** : A mechanism that puts something into action.

**Electrical actuators** : **DC servomotors**

**AC motors**

**Stepper motors**

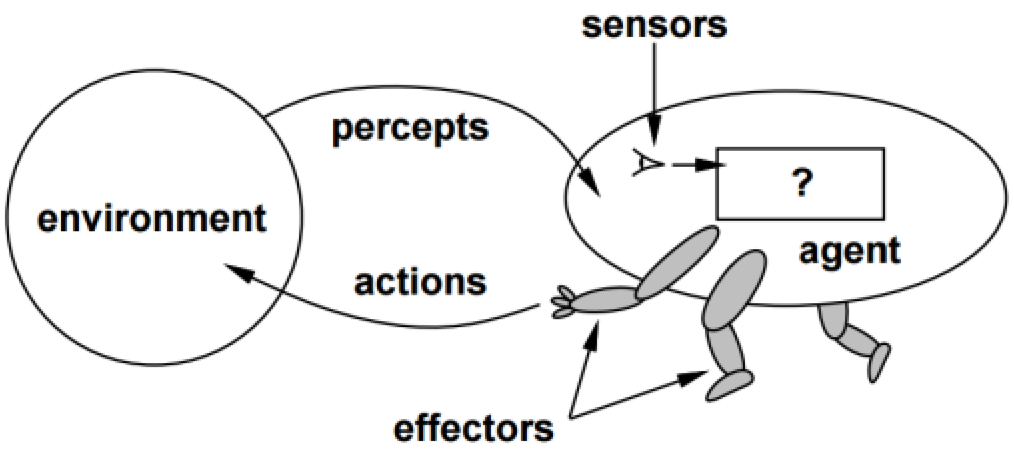
**Perception**: what agent see the environment.




Agents interact with environments through sensors and actuators.

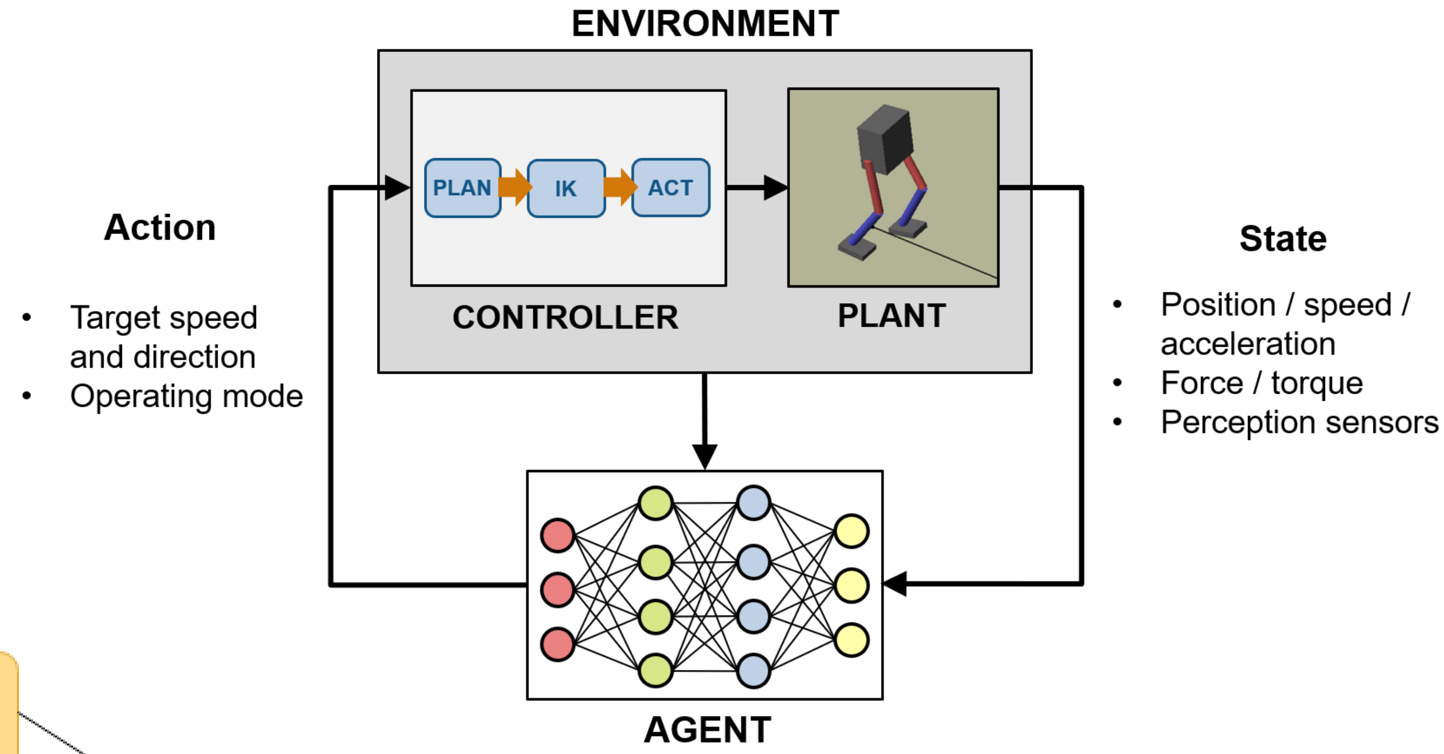
# Agents in AI

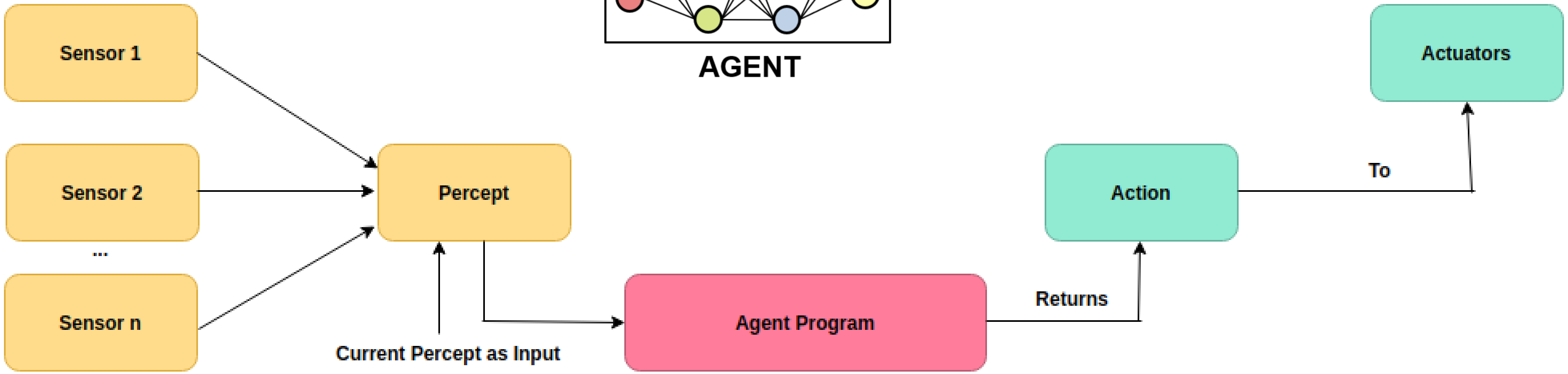
- A human agent has eyes, ears, and other organs for sensors and hands, legs, vocal tract, and so on for actuators
- A robotic agent might have cameras and infrared range finders for sensors and various motors for actuators
- A software agent (softbots) receives keystrokes, file contents and network packets as sensory inputs and acts on the environment by displaying on the screen, writing files and sending network packets



# Agents in AI

➢ A **robotic agent** might have cameras and infrared range finders for sensors and various motors for actuators



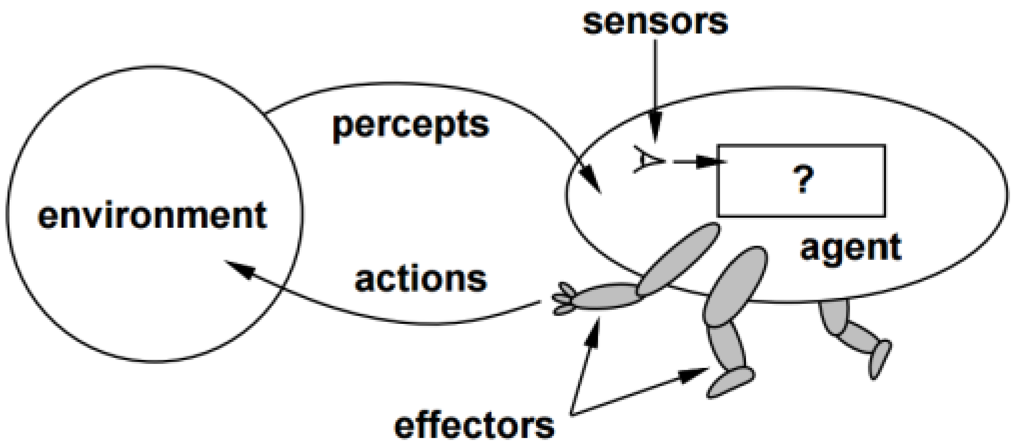
# Agents in AI

➢ A software agent (softbots) receives keystrokes, file contents and network packets as sensory inputs and acts on the environment by displaying on the screen, writing files and sending network packets

A software agent is a set of programs that are designed to do particular tasks.

Example 1: a software agent can check the contents of received e-mails and classify them into different categories (junk, less important, important, very important and so on).

Example 2: Another example of a software agent is a search engine used to search the World Wide Web and find sites that can provide information about a requested subject.



# Agents in AI

- Computer agents (or software agents) have several characteristics which distinguish them from mere programs.
  - Capability to work on their own (autonomy)
  - Perceiving their environment
  - Persisting over a prolonged time period
  - Adapting to change (adaptivity)
  - Capable of taking on another's goal (goal oriented)
  - Transportable over networks (mobility)
  - Ability to interact with humans, systems and other agents (communicative)
  - Ability to learn

# Agents in AI

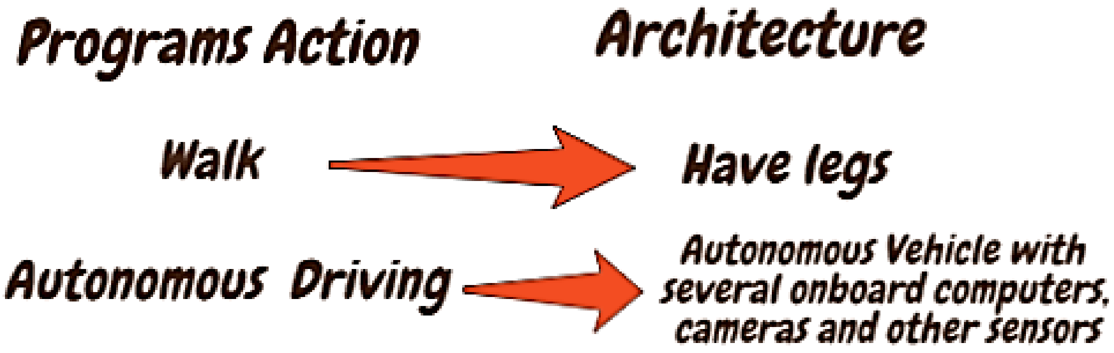
**A robot with only visual sensors in an environment without light? Is it an agent or not?**

# The Structure of Agents

- The job of AI is to design an agent program that implements the agent function the mapping from percepts to actions. We assume this program will run on some sort of computing device with physical sensors and actuators—we call this the agent architecture

**agent = architecture + program**

- Obviously, the program we choose has to be one that is appropriate for the architecture. If the program is going to recommend actions like Walk, the architecture had better have legs.




- In general, the architecture makes the percepts from the sensors available to the program, runs the program, and feeds the program's action choices to the actuators as they are generated.

# Good Behavior : The Concept of Rationality

- A rational agent is one that does the right thing
- Obviously, doing the right thing is better than doing the wrong thing, but what does it mean to do the right thing?
- **The right action is the one that will cause the agent to be most successful**
- **An agent should show these things to be rational:**

- ✓ Performance measures
- ✓ Rationality
- ✓ Omniscience, learning, and autonomy

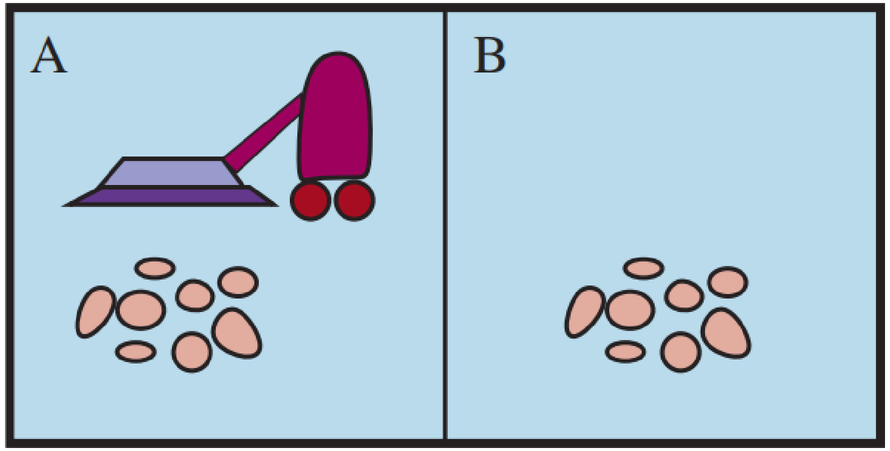
# Rational Agents

- **Performance measures:** **An objective criterion for success of an agent's behavior.**

**AI has generally stuck to one notion called consequentialism: we evaluate an agent's behavior by its consequences**

**e.g., 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.**

| Agent Type | Performance Measure | Environment | Actuators | Sensors |
|---|---|---|---|---|
| Taxi driver | Safe, fast, legal, comfortable trip, maximize profits, minimize impact on other road users | Roads, other traffic, police, pedestrians, customers, weather | Steering, accelerator, brake, signal, horn, display, speech | Cameras, radar, speedometer, GPS, engine sensors, accelerometer, microphones, touchscreen |



# Rational Agents

**What is rational at any given time depends on four things:**

- **The performance measure that defines the criterion of success.**
- **The agent’s prior knowledge of the environment.**
- **The actions that the agent can perform.**
- **The agent’s percept sequence to date**

**Rational Agent : For each possible percept sequence, a rational agent should select an action that is expected to maximize its performance measure, given the evidence provided by the percept sequence and whatever built-in knowledge the agent has.**

# Rational Agents

- **Omniscience, learning, autonomy**
  - Rationality is distinct from omniscience (all-knowing with infinite knowledge)
    - Choose action that maximizes expected value of perf. measure given percept to date
  - Agents can perform actions in order to modify future percepts so as to obtain useful information (information gathering, exploration)
  - An agent is autonomous if its behavior is determined by its own experience (with ability to learn and adapt)

- **We need to be careful to distinguish between rationality and omniscience. An omniscient agent knows the actual outcome of its actions and can act accordingly; but omniscience is impossible in reality.**
- **Rationality maximizes expected performance, while perfection maximizes actual performance**

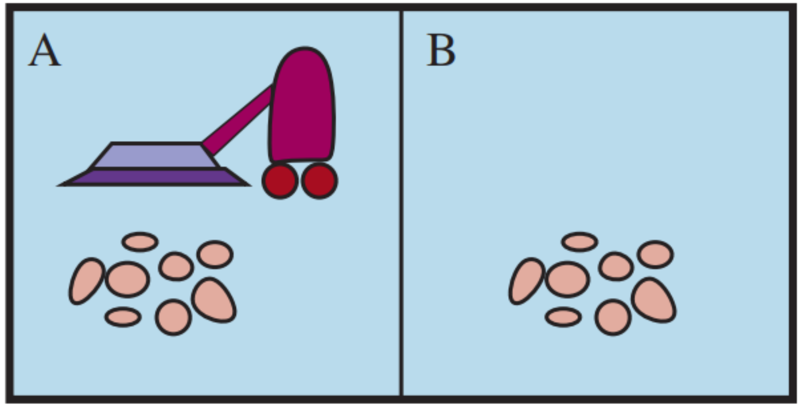
# The Concept of Rationality

- **Agent Function (percepts ==> actions)**
  - Maps from percept histories to actions $f: \mathcal{P}^* \rightarrow \mathcal{A}$
  - The agent program runs on the physical architecture to produce the function $f$
  - agent = architecture + program

```
Action := Function(Percept Sequence)
If (Percept Sequence) then do Action
```

- **Example: A Simple Agent Function for Vacuum World**

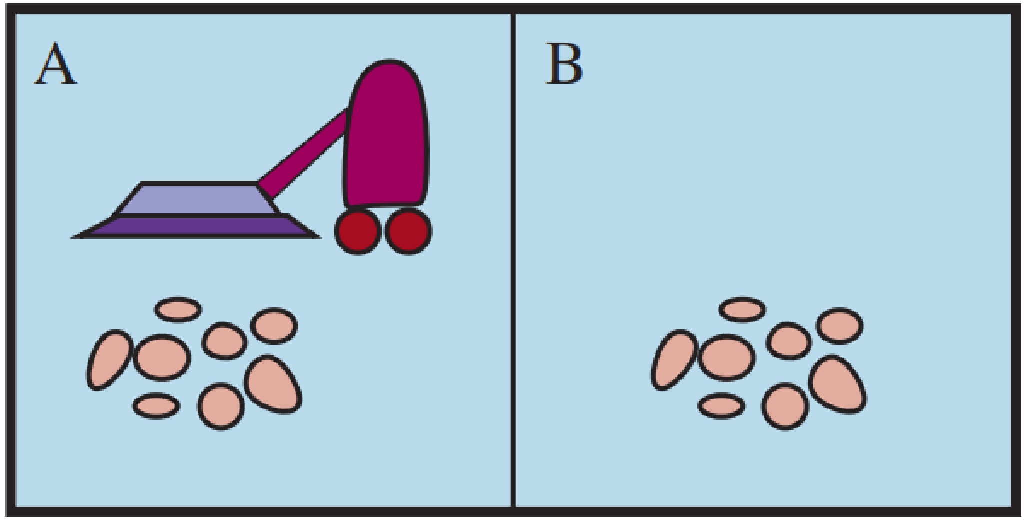
```
If (current square is dirty) then suck
Else move to adjacent square
```



# Kinds of Agent Programs

- **Four basic kinds of agent programs:**
  1) **Simple reflex agents**
  2) **Model-based reflex agents**
  3) **Goal-based agents**
  4) **Utility-based agents**

- **Each kind of agent program combines particular components in particular ways to generate actions**




**A vacuum-cleaner world with just two locations Each location can be clean or dirty, and the agent can move left or right and can clean the square that it occupies**

| 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* |
| ⋮ | ⋮ |
| $[A, Clean], [A, Clean], [A, Clean]$ | *Right* |
| $[A, Clean], [A, Clean], [A, Dirty]$ | *Suck* |
| ⋮ | ⋮ |

# Simple reflex agents

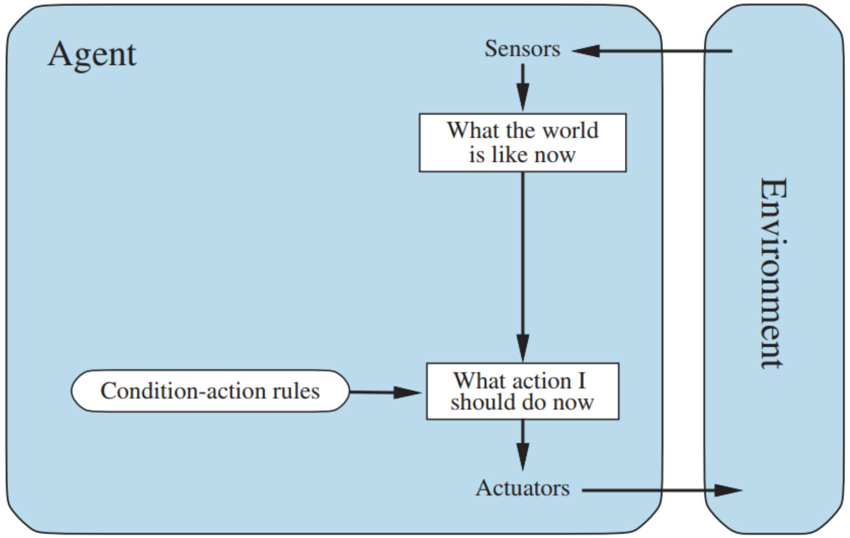
- The **simplest** kind of agent is the **simple reflex agent**
- These agents **select actions** on the **basis of the current percept**, ignoring the rest of the percept history
- For example, the **vacuum agent** whose agent function is tabulated is a simple reflex agent, because **its decision is based only on the current location and on whether that location contains dirt**
- **They are stateless devices which do not have memory of past world states.**

**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*

The agent program for a simple reflex agent in the two-location vacuum environment

**Perception-Action-Cycle**




Rectangles denotes the current internal state of the agent's decision process, and ovals to represent the background information used in the process

# Model-based reflex agents

**Or**

**Reflex Agents with memory (Model-Based)**

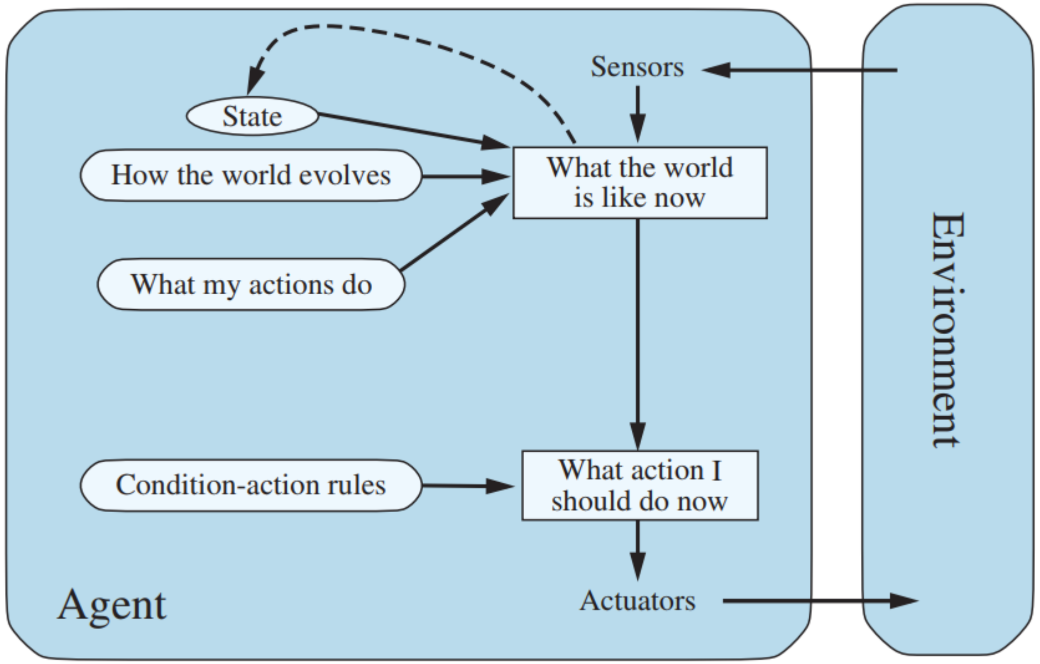
- **That is, the agent should maintain some sort of internal state that depends on the percept history and thereby reflects at least some of the unobserved aspects of the current state.**
- **Have internal state which is used to keep track of past states of the world.**

```
function MODEL-BASED-REFLEX-AGENT(percept) returns an action
  persistent: state, the agent's current conception of the world state
              transition_model, a description of how the next state depends on
                  the current state and action
              sensor_model, a description of how the current world state is reflected
                  in the agent's percepts
              rules, a set of condition–action rules
              action, the most recent action, initially none

  state ← UPDATE-STATE(state, action, percept, transition_model, sensor_model)
  rule ← RULE-MATCH(state, rules)
  action ← rule.ACTION
  return action
```

**Figure 2.12** A model-based reflex agent. It keeps track of the current state of the world, using an internal model. It then chooses an action in the same way as the reflex agent.

**Perception-Action-Cycle**

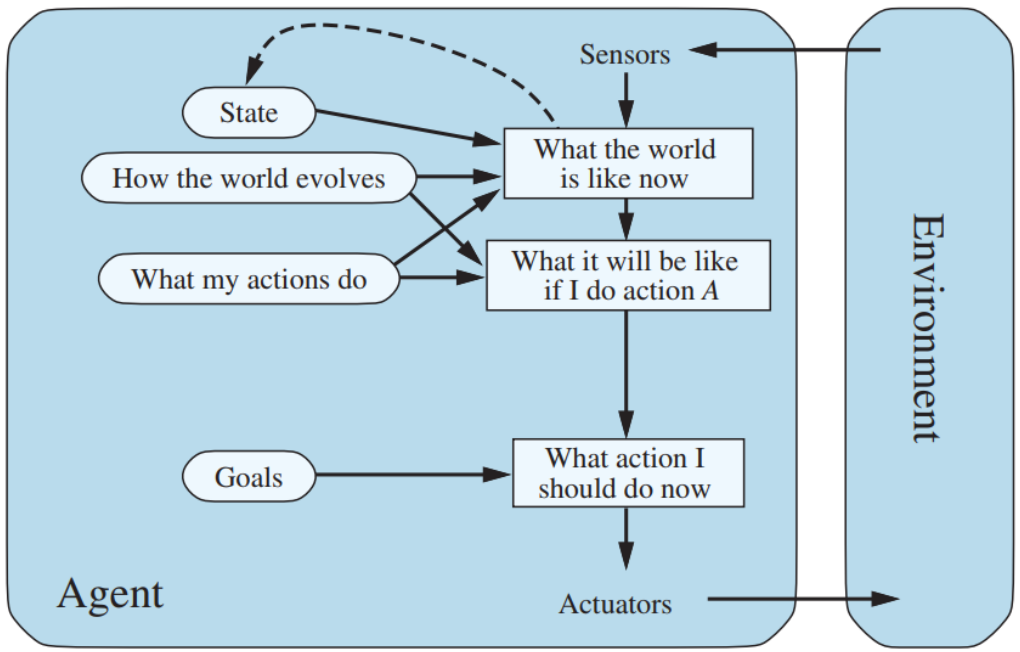


# Goal-based agents/Agents with goals

- **Knowing something about the current state of the environment is not always enough to decide what to do?**
- **The agent needs to know its goal which describes desirable situations.**
- These agents may have to **consider a long sequence of possible actions before deciding whether the goal is achieved or not.** Such considerations of different scenario are called searching and planning, which makes an agent proactive.

**Example: at a road junction, the taxi can turn left, turn right, or go straight on. The correct decision depends on where the taxi is trying to get to. In other words, as well as a current state description, the agent needs some sort of goal information that describes situations that are desirable—for example, being at a particular destination. The agent program can combine this with the model (the same information as was used in the model-based reflex agent) to choose actions that achieve the goal.**

**Perception-Action-Cycle**



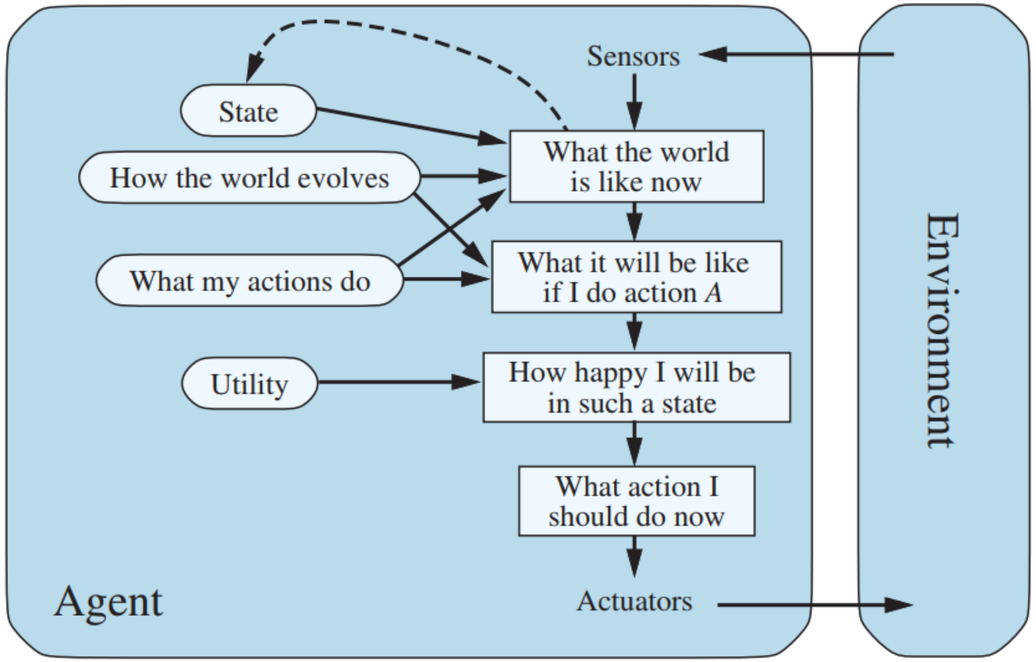

**It keeps track of the world state as well as a set of goals it is trying to achieve, and chooses an action that will (eventually) lead to the achievement of its goals.**

# 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.

- **These agents are similar to the goal-based agent but provide an extra component of utility measurement which makes them different by providing a measure of success at a given state.**
- **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 utility function maps each state to a real number to check how efficiently each action achieves the goals.**

**Perception-Action-Cycle**




**An agent that chooses actions to maximize its utility will be rational according to the external performance measure**

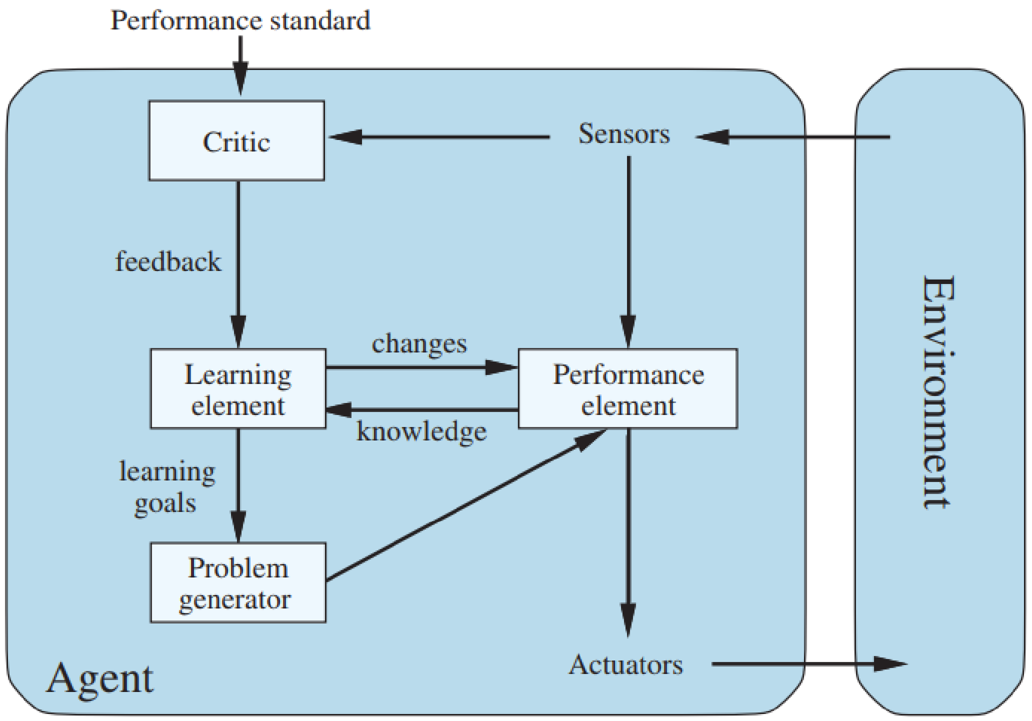
**Note:** **The word "utility" here refers to "the quality of being useful," not to the electric company or waterworks**

- **quicker, safer, more reliable, or cheaper than others. Goals just provide a crude binary distinction between "happy" and "unhappy" states.**

# Learning agents

**Any type of agent (model-based, goal-based, utility-based, etc.) can be built as a learning agent**

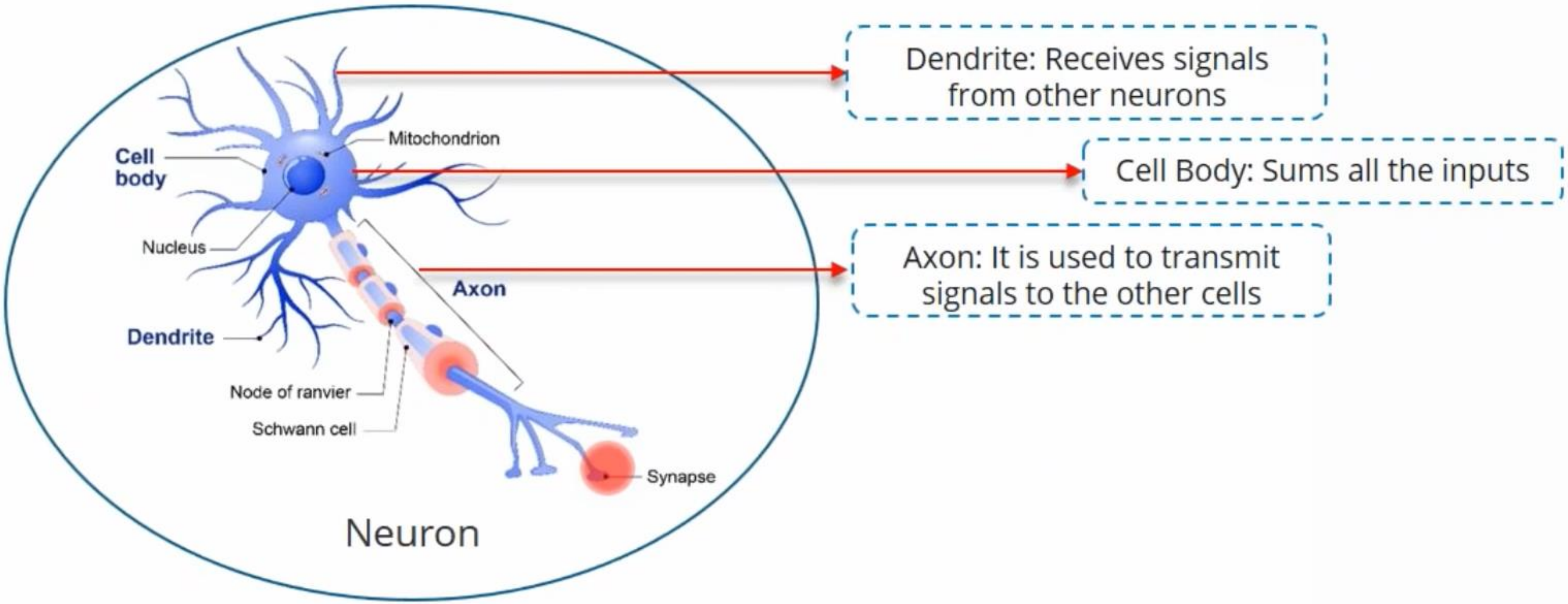
- All agents can improve their performance through learning.
- It starts to act with basic knowledge and then able to act and adapt automatically through learning.
- A learning agent has mainly four conceptual components, which are:
  - **Learning element:** It is responsible for making improvements by learning from environment
  - **Critic:** Learning element takes feedback from critic which describes that 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.




**The "performance element" box represents what we have previously considered to be the whole agent program. Now, the "learning element" box gets to modify that program to improve its performance.**

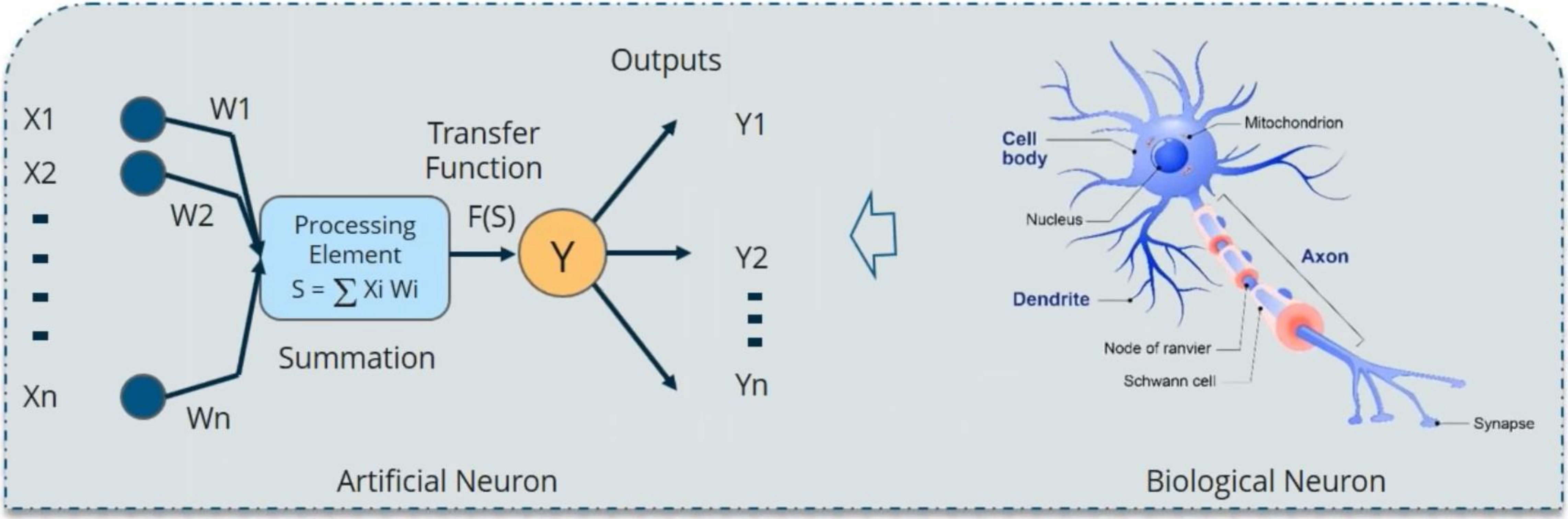
# Learning agents

*The building block of a neural net is the neuron. An artificial neuron works much the same way the biological one does.*



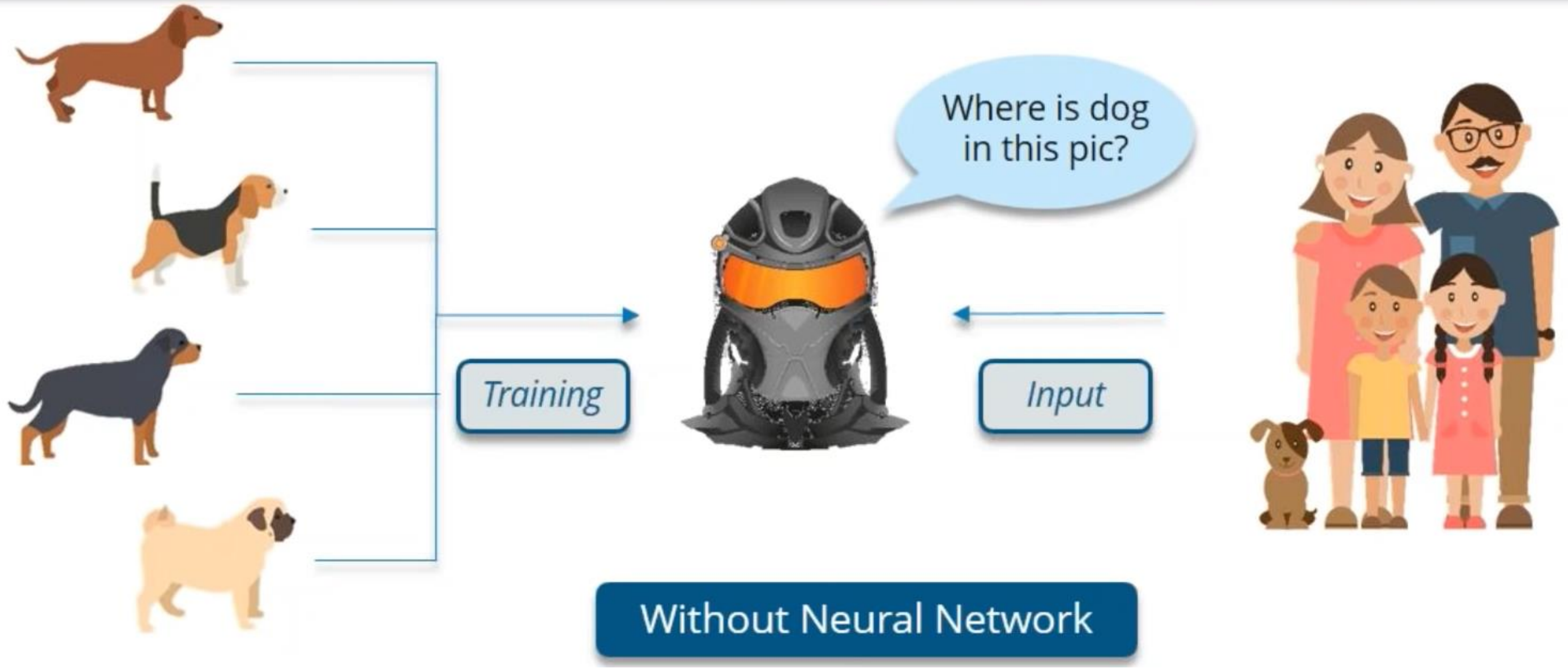
# Learning agents

To get started, I'll explain artificial neuron called a *perceptron*.



# Learning agents

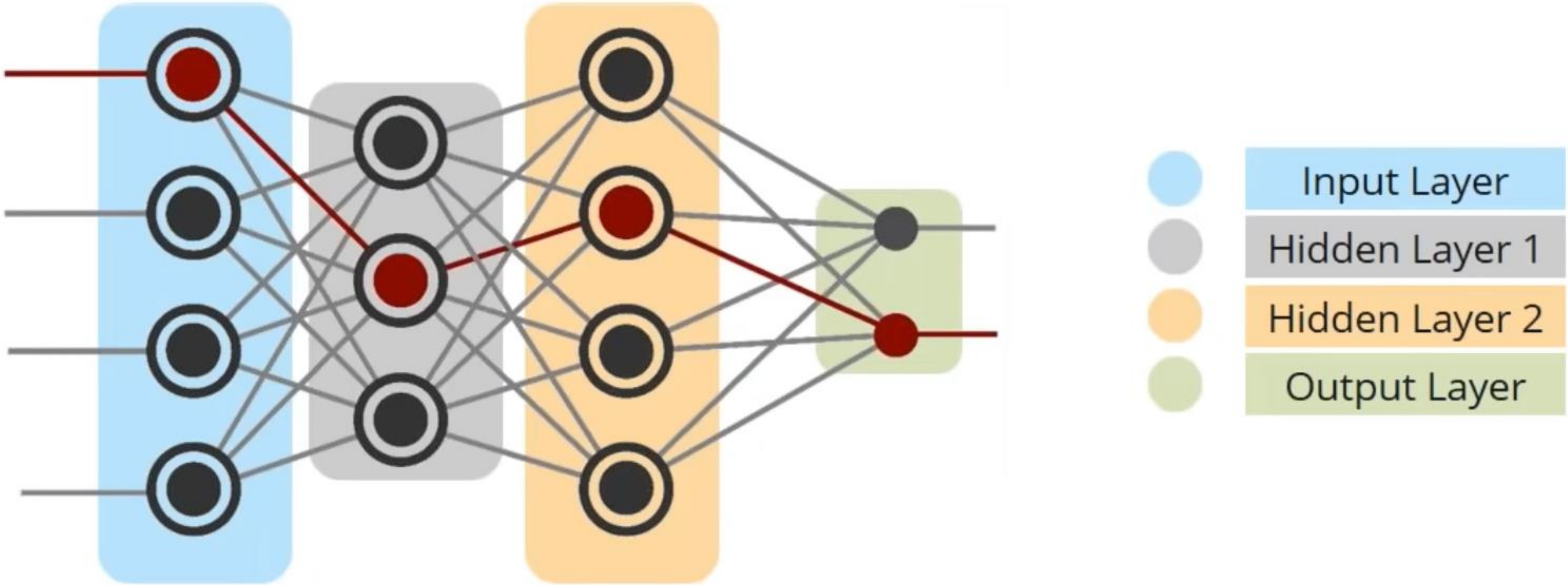
*Artificial Neural Networks (ANNs)* are computing systems inspired by the biological neural networks that constitute animal brains. Such systems learn (progressively improve performance) to do tasks by considering examples, generally without task-specific programming.



# Learning agents

## Multilayer Perceptron – Artificial Neural Network

As you know our brain is made up of millions of neurons, so a Neural Network is really just a composition of *perceptrons*, connected in different ways and operating on different activation functions.



# Artificial Intelligence


By

**Dr. Manoj Kumar**

**University School of Automation and Robotics**
**GGSIP University, East Campus, Delhi, India**

# Environment in AI

- **An environment is everything in the world which surrounds the agent, but it is not a part of an agent itself.**
- **An environment can be described as a situation in which an agent is present.**
- **The environment is where agent lives, operate and provide the agent with something to sense and act upon it.**

# Specifying the task environment

| Agent Type | Performance Measure | Environment | Actuators | Sensors |
|---|---|---|---|---|
| Medical diagnosis system | Healthy patient, reduced costs | Patient, hospital, staff | Display of questions, tests, diagnoses, treatments | Touchscreen/voice entry of symptoms and findings |
| Satellite image analysis system | Correct categorization of objects, terrain | Orbiting satellite, downlink, weather | Display of scene categorization | High-resolution digital camera |
| Part-picking robot | Percentage of parts in correct bins | Conveyor belt with parts; bins | Jointed arm and hand | Camera, tactile and joint angle sensors |
| Refinery controller | Purity, yield, safety | Refinery, raw materials, operators | Valves, pumps, heaters, stirrers, displays | Temperature, pressure, flow, chemical sensors |
| Interactive English tutor | Student's score on test | Set of students, testing agency | Display of exercises, feedback, speech | Keyboard entry, voice |

# Specifying the task environment

- We had to specify the performance measure, the environment, and the agent's actuators and sensors. We group all these under the heading of the task environment.

- Use PEAS to describe task environment

  Performance measure

  Environment

  Actuators

  Sensors

# Properties of task environments

| Agent Type | Performance Measure | Environment | Actuators | Sensors |
|---|---|---|---|---|
| Taxi driver | Safe, fast, legal, comfortable trip, maximize profits, minimize impact on other road users | Roads, other traffic, police, pedestrians, customers, weather | Steering, accelerator, brake, signal, horn, display, speech | Cameras, radar, speedometer, GPS, engine sensors, accelerometer, microphones, touchscreen |

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

# Environment Properties

1) Fully observable vs. partially observable
2) Deterministic vs. stochastic / Non-deterministic
3) Episodic vs. sequential
4) Single agent vs. multiagent
5) Static vs. dynamic
6) Discrete vs. continuous
7) Known vs. Unknown
8) Accessible vs Inaccessible

# Environment Properties

## 1. Fully observable vs Partially Observable:

- If an **agent sensor** can sense or access the complete state of an environment at each point of time then it is **a fully observable** environment, else it is **partially observable**.
- A fully observable environment is easy as there is **no need to maintain the internal state** to keep track history of the world.
- An **agent with no sensors** in all environments then such an environment is called as **unobservable**.

**Example:** A vacuum agent with only a local dirt sensor cannot tell whether there is dirt in other squares, and an automated taxi cannot see what other drivers are thinking.

# Environment Properties

**2. Deterministic vs Stochastic:**

- If an agent's current state and selected action can completely determine the next state of the environment, then such environment is called a **deterministic environment**.
- A **stochastic (Nondeterministic) environmen**t is random in nature and cannot be determined completely by an agent.
- In **a deterministic, fully observable environment**, agent does not need to worry about uncertainty.

**Example:** Taxi driving is clearly nondeterministic in this sense, because one can never predict the behavior of traffic exactly

# Environment Properties

## 3. Episodic vs Sequential:

- In an **episodic environment**, there is a series of one-shot actions, and only the current percept is required for the action.
- In each episode the agent receives a percept and then performs a single action.
- Crucially, the next episode does not depend on the actions taken in previous episodes

**Example: An agent that has to spot defective parts on an assembly line bases each decision on the current part, regardless of previous decisions; moreover, the current decision doesn't affect whether the next part is defective.**

- However, in Sequential environment, an agent requires memory of past actions to determine the next best actions.

**Example: Chess and taxi driving are sequential: in both cases, short-term actions can have long-term consequences.**

**Episodic environments are much simpler than sequential environments because the agent does not need to think ahead.**

# Environment Properties

**4. Single-agent vs Multi-agent:**

- If only one agent is involved in an environment, and operating by itself then such an environment is called single agent environment.
- However, if multiple agents are operating in an environment, then such an environment is called a multi-agent environment.
- The agent design problems in the multi-agent environment are different from single agent environment.

**Example: an agent solving a crossword puzzle by itself is clearly in a single-agent environment, whereas an agent playing chess is in a two agent environment.**

# Environment Properties

**5. Static vs Dynamic:**

- If the environment can change itself while an agent is deliberating, then such environment is called a dynamic environment else it is called a static environment.
- Static environments (**The environment is unchanged while an agent is deliberating**) are easy to deal because an agent does not need to continue looking at the world while deciding for an action.
- However for dynamic environment, agents need to keep looking at the world at each action.

**Example: Taxi driving is an example of a dynamic environment, the other cars and the taxi itself keep moving while the driving algorithm dithers about what to do next. Chess, when played with a clock, is semidynamic. Crossword puzzles are static environment.**

# Environment Properties

**6. Discrete vs Continuous:**

- If in an environment there are a finite number of percepts and actions that can be performed within it, then such an environment is called a discrete environment else it is called continuous environment.
- A chess game comes under discrete environment as there is a finite number of moves that can be performed.
- A self-driving car is an example of a continuous environment.

# Environment Properties

**7. Known vs Unknown:**

- Known and unknown are not actually a feature of an environment, but it is an agent's state of knowledge to perform an action.
- In a known environment, the results for all actions are known to the agent. While in unknown environment, agent needs to learn how it works in order to perform an action.
- It is quite possible that a known environment to be partially observable and an Unknown environment to be fully observable.

# Environment Properties

**8. Accessible vs Inaccessible:**

- If an agent can obtain complete and accurate information about the state's environment, then such an environment is called an Accessible environment else it is called inaccessible.
- An empty room whose state can be defined by its temperature is an example of an accessible environment.
- Information about an event on earth is an example of Inaccessible environment.

# Environment Examples

| 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 |
| English tutor | Partially | Multi | Stochastic | Sequential | Dynamic | Discrete |

If the environment itself does not change with the passage of time but the agent's performance score does, then we say the environment is **semidynamic.**

# Environment Examples

static AI environments rely on data-knowledge sources that don’t change frequently over time. Speech analysis is a problem that operates on static AI environments. Contrasting with that model, dynamic AI environments such as the vision AI systems in drones deal with data sources that change quite frequently. Dynamic AI environments often need to enable faster and more regular training of AI agents.

# Artificial Intelligence

By

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# Problem Solving Agents

- **Problem-solving agent is one kind of goal-based agent that decides what to do by finding sequences of actions that leads to desirable states.**
- **It first formulates a goal and a problem.**
- **An agent may need to plan ahead: to consider a sequence of actions that form a path to a goal state.**
- **Such an agent is called a problem-solving agent, and the computational process it undertakes is called search.**

# Problem Solving Agents

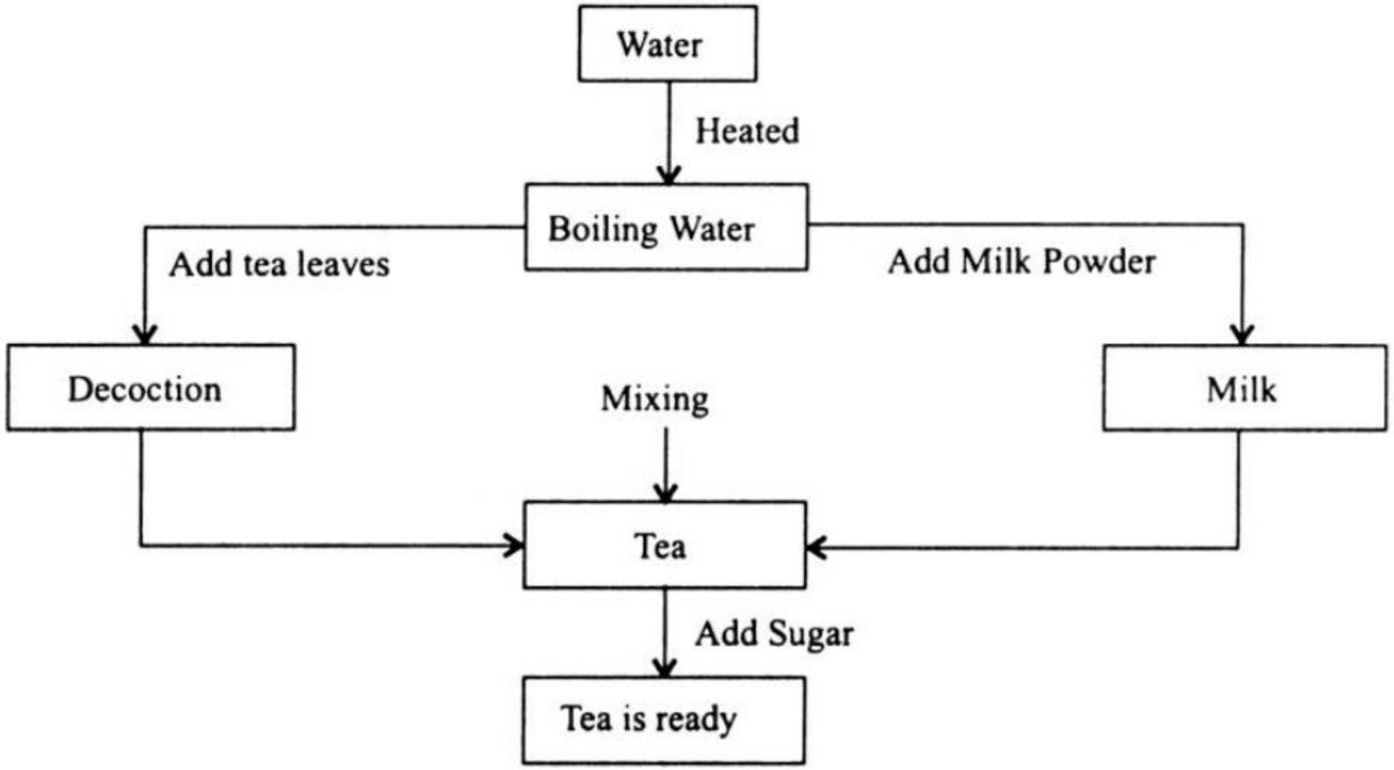
- An agent with several immediate options of unknown value can decide what to do first by examining different sequence of actions that lead to states of known value.
- It then chooses the best sequence.
- This process of looking for such a sequence is called search.
- In AI search refers to a large number of core ideas that deals with deduction, inference, planning, common sense reasoning, theorem proving and related ideas.
- Then the agent executes the actions one at a time. This is called the execution phase.
- When this is complete, it formulates another goal and starts over. It assumes that the solution it has found will always work.

# Problem Solving Agents

Suppose we are asked to prepare a cup of tea; what should be one?

**All the ingredients such as tea leaves, milk powder, sugar, kettle, heating arrangement must be made available**

1. **Boil required quantity of water**
2. **Take some of the boiled water in a cup, add necessary amount of tea leaves to make decoction (extraction of flavour by boiling).**
3. **Add milk powder to some boiling water to make milk.**
4. **Mix decoction and milk.**
5. **Add sugar to your taste.**
6. **Tea is prepared.**




State-space representation for tea making

# Agents in AI

**We will assume our agents always have access to information about the world**

**With that information, the agent can follow this four-phase problem-solving process:**

- **Goal formulation:** The agent adopts the goal of reaching Bucharest. Goals organize behavior by limiting the objectives and hence the actions to be considered.

- **Problem formulation:** The agent devises a description of the states and actions necessary to reach the goal—an abstract model of the relevant part of the world. For our agent, one good model is to consider the actions of traveling from one city to an adjacent city, and therefore the only fact about the state of the world that will change due to an action is the current city.

- **Search:** Before taking any action in the real world, the agent simulates sequences of actions in its model, searching until it finds a sequence of actions that reaches the goal. Such a sequence is called a solution. The agent might have to simulate multiple sequences that do not reach the goal, but eventually, it will find a solution (such as going from Arad to Sibiu to Fagaras to Bucharest), or it will find that no solution is possible.

- **Execution:** The agent can now execute the actions in the solution, one at a time.

# Search problems and solutions

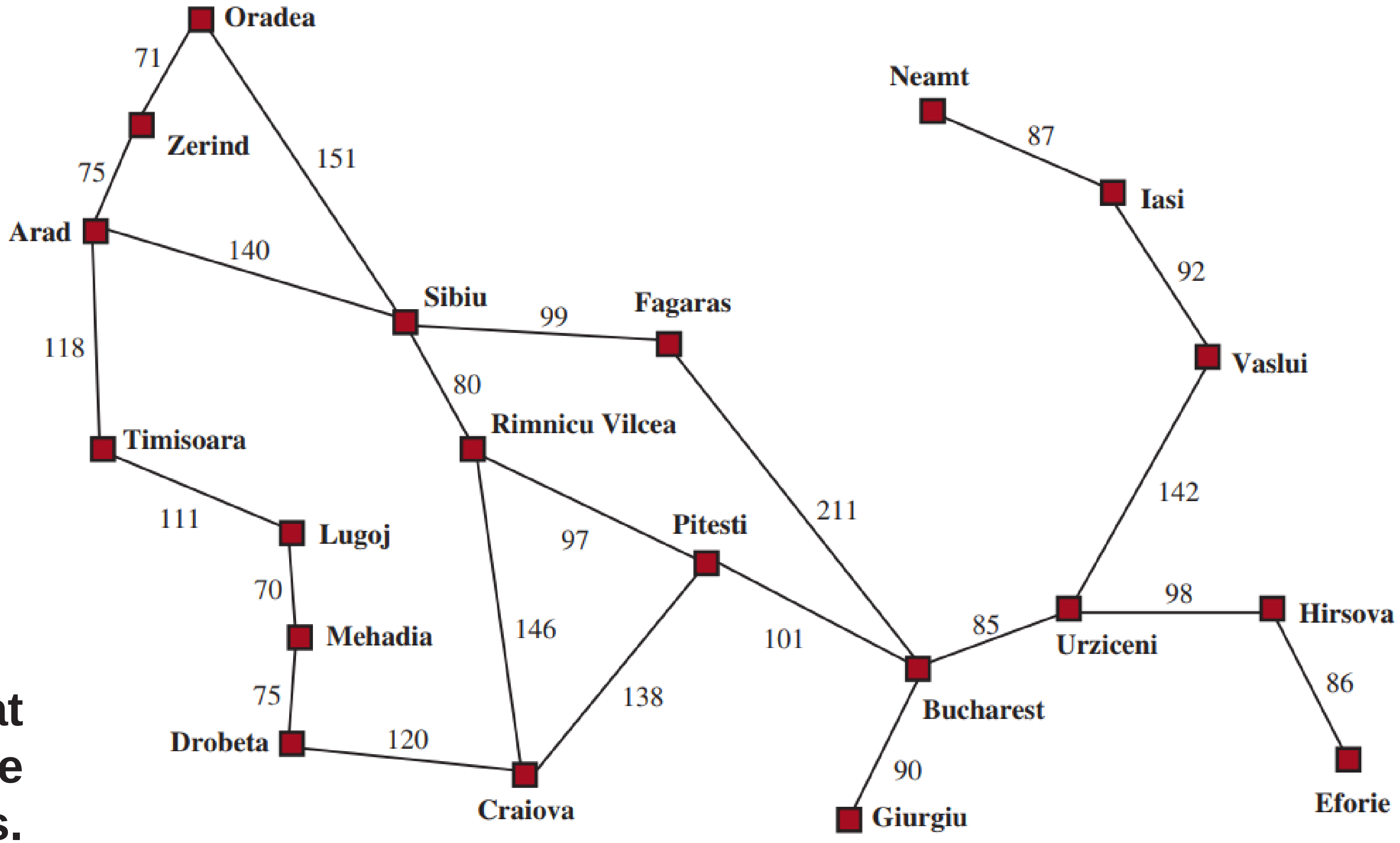
A search problem can be defined formally as follows:

- A set of possible **states** that the environment can be in. We call this the **state space**.
- The **initial state** that the agent starts in. For example: Arad
- A set of one or more **goal states**.
- The actions available to the agent. Given a state s, **ACTIONS(s)** returns a finite set of actions that can be executed in s

*ACTIONS(Arad) = {ToSibiu,ToTimisoara,ToZerind}.*

- A **transition model**, which describes what each action does. RESULT(s, a) returns the state that results from doing action in state s. For example

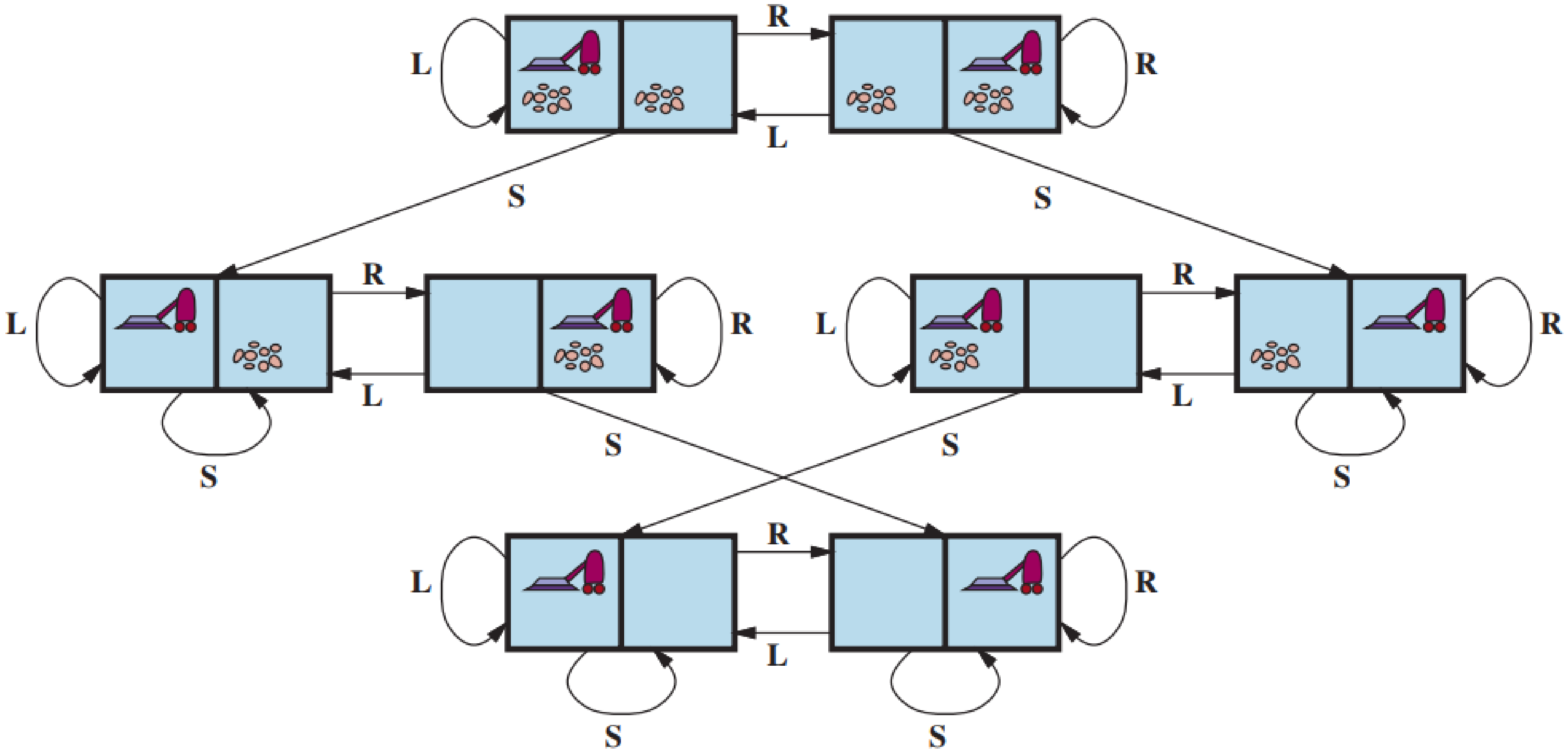
*RESULT(Arad, ToZerind) = Zerind .*




A simplified road map of part of Romania, with road distances in miles.

# Example Problem-1: The vacuum world

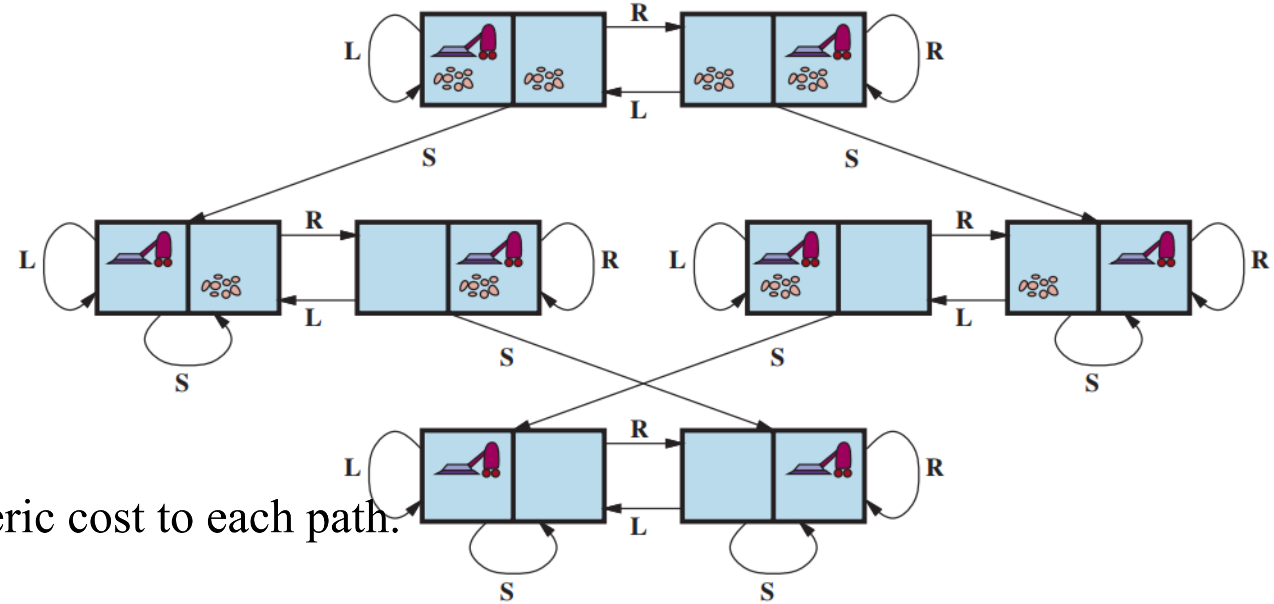
- A grid world problem is a two-dimensional rectangular array of square cells in which agents can move from cell to cell.
- Typically, the agent can move to any obstacle-free adjacent cell horizontally or vertically and, in some problems diagonally.




The state-space graph for the two-cell vacuum world. There are 8 states and three actions for each state: L = Left, R = Right, S = Suck.

# Example Problem-1: The vacuum world

- **States:** A state of the world says which objects are in which cells. For the vacuum world, the objects are the agent and any dirt. In the simple two-cell version, the agent can be in either of the two cells, and each cell can either contain dirt or not, so there are 2 · 2 · 2 = 8 states (see Figure 3.2). In general, a vacuum environment with n cells has $n \cdot 2^n$ states.
- **Initial state:** Any state can be designated as the initial state.
- **Goal states**: The states in which every cell (both cells are) is clean.
- **Actions:** In the two-cell world we defined three actions: Suck, move Left, and move Right.
- **Transition model:** Suck removes any dirt from the agent's cell; Forward moves the agent ahead of one cell in the direction it is facing unless it hits a wall, in which case the action has no effect. Backward moves the agent in the opposite direction, while TurnRight and TurnLeft change the direction, it is facing by $90^\circ$.
- **Action cost:** Each action costs 1.




A **path cost** function that assigns a numeric cost to each path.

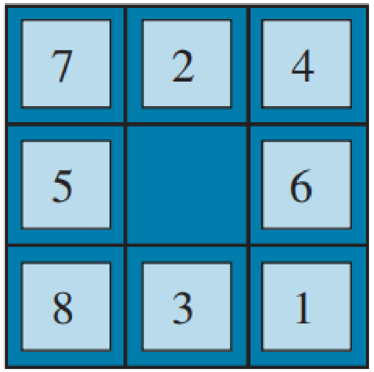
# Example Problem-2: Sliding-tile puzzle

**The standard formulation of the 8 puzzle is as follows:**

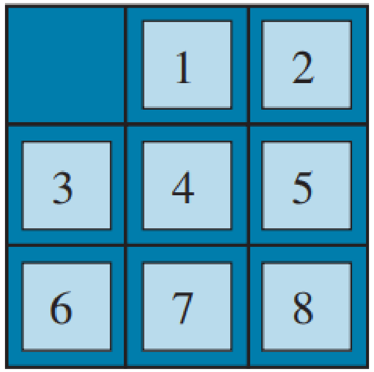
- **States:** A state description specifies the location of each of the tiles.
- **Initial state:** Any state can be designated as the initial state.
- **Goal state:** Although any state could be the goal, we typically specify a state with the numbers in order
- **Actions:** While in the physical world, it is a tile that slides, the simplest way of describing an action is to think of the blank space moving Left, Right, Up, or Down. If the blank is at an edge or corner, then not all actions will be applicable.
- **Transition model:** Maps a state and action to a resulting state; for example, if we apply Left to the start state in Figure (a), the resulting state has the 5 and the blank switched.

- **Action cost/path cost :** Each action/step costs 1.

**path cost is the number of steps in the path**

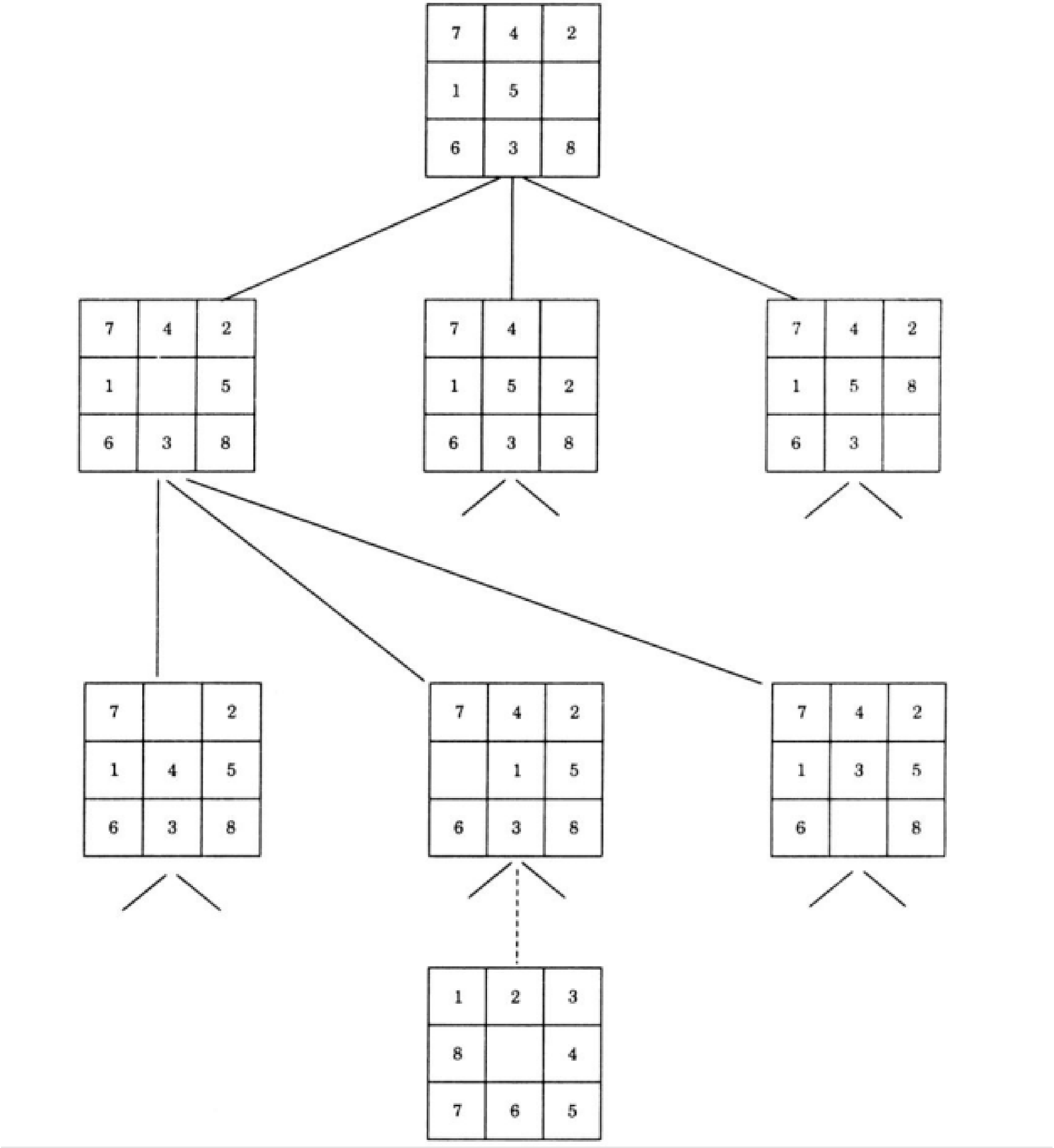


Start State
(a)



Goal State

# Example Problem-2: Sliding-tile puzzle



# Example Problem-3: Real-world problems

## Route-finding problem

- **States:** Each state obviously includes a location (e.g., an airport) and the current time. Furthermore, because the cost of an action (a flight segment) may depend on previous segments, their fare bases, and their status as domestic or international, the state must record extra information about these “historical” aspects.
- **Initial state:** The user’s home airport.
- **Goal state:** A destination city. Sometimes the goal can be more complex, such as “arrive at the destination on a nonstop flight.”
- **Actions:** Take any flight from the current location, in any seat class, leaving after the current time, leaving enough time for within-airport transfer if needed.
- **Transition model:** The state resulting from taking a flight will have the flight’s destination as the new location and the flight’s arrival time as the new time.
- **Action cost:** A combination of monetary cost, waiting time, flight time, customs and immigration procedures, seat quality, time of day, type of airplane, frequent-flyer reward points, and so on.