ARTIFICIAL INTELLIGENCE & EXPERT SYSTEMS

CSE-321 || Lecture-01

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DEFINITION OF AI

Artificial Intelligence (AI) is a way to make machines think and behave intelligently.

- These machines are controlled by software inside them, so AI has a lot to do with intelligent software programs that control these machines.

- It is a science of finding theories and methodologies that can help machines understand the world and accordingly react to situations in the same way that humans do.

- AI is closely related to the study of human brain. Researchers believe that AI can be accomplished by understanding how the human brain works.

- By mimicking the way the human brain learns, thinks, and takes action, we can build a machine that can do the same.

- This can be used as a platform to develop intelligent systems that are capable of learning.

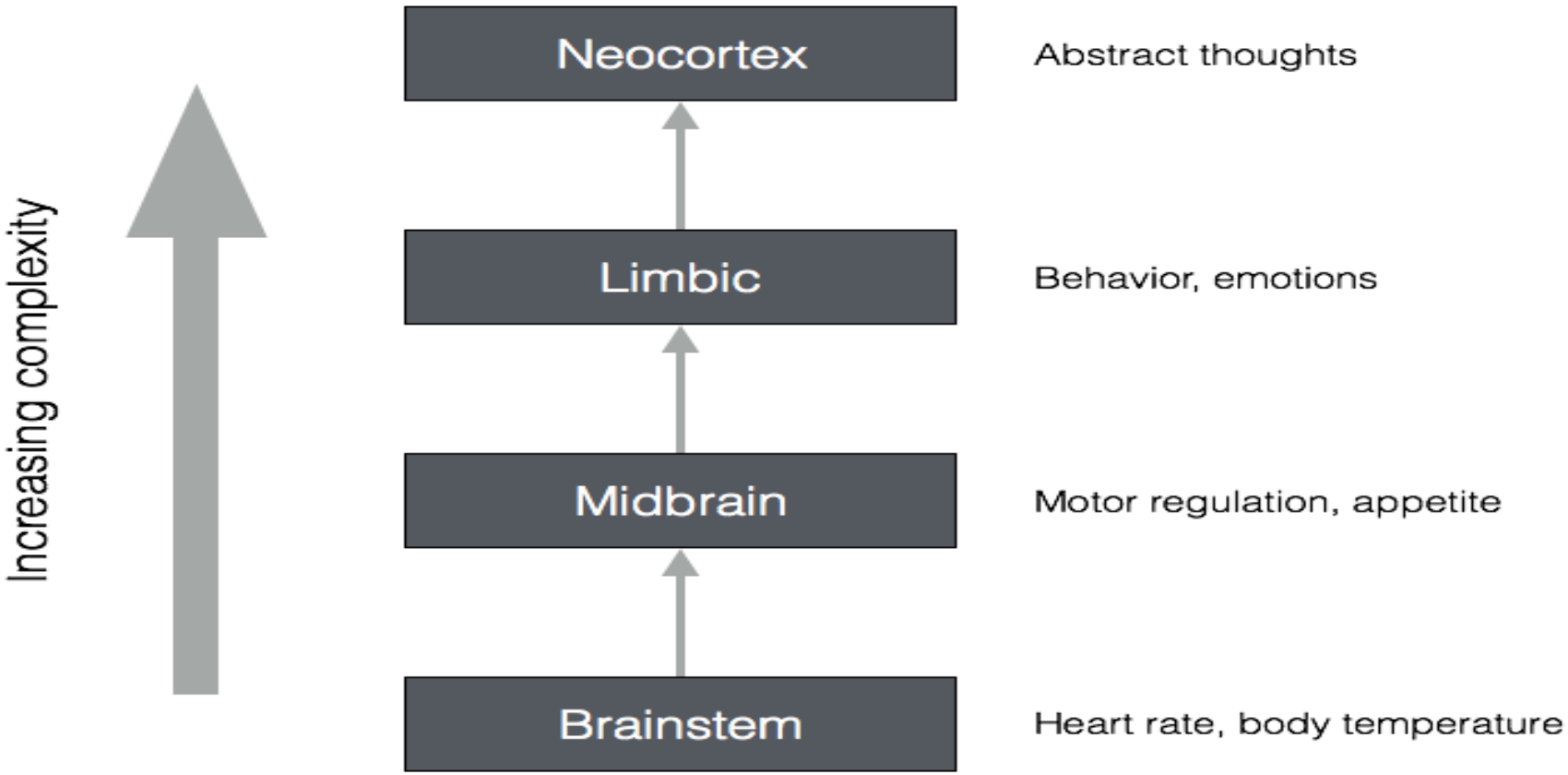
WHY DO WE NEED TO STUDY AI?

AI has the ability to impact every aspect of our lives.

- The field of AI tries to understand **patterns and behaviors** of entities.
- With AI, we want to build smart systems and understand the concept of intelligence as well.
- The intelligent systems that we construct are very useful in understanding how an intelligent system like our brain goes about constructing another intelligent system.

WHY DO WE NEED TO STUDY AI?

Let's take a look at how our brain processes information:

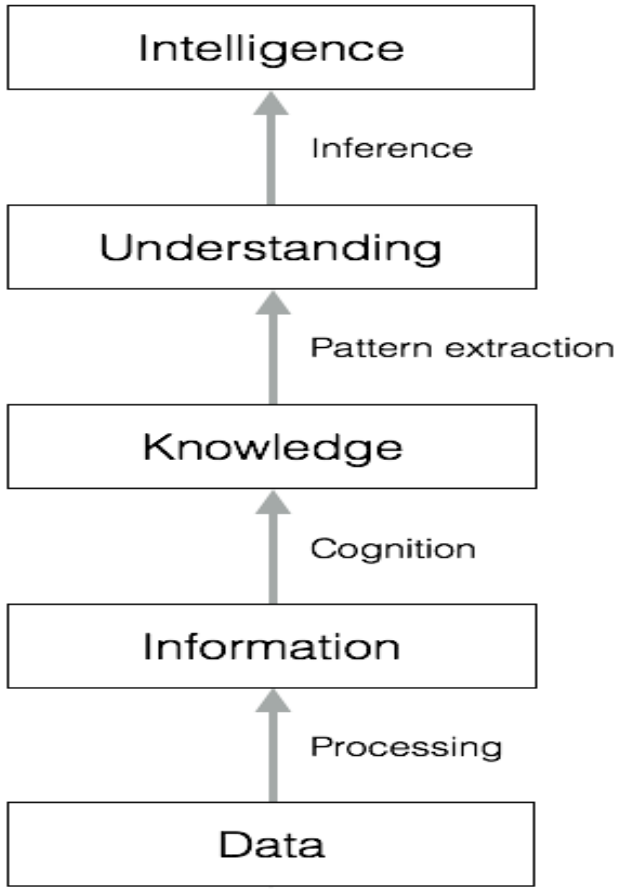


WHY DO WE NEED TO STUDY AI?

- We can recognize **objects**, understand languages, learn new things, and perform many more sophisticated tasks with our brain.
- How does the human brain do this?
- When you try to do this with a machine, you will see that it falls way behind!

WHY DO WE NEED TO STUDY AI?

Let's see how raw data gets converted to wisdom through various levels of processing:



APPLICATIONS OF AI

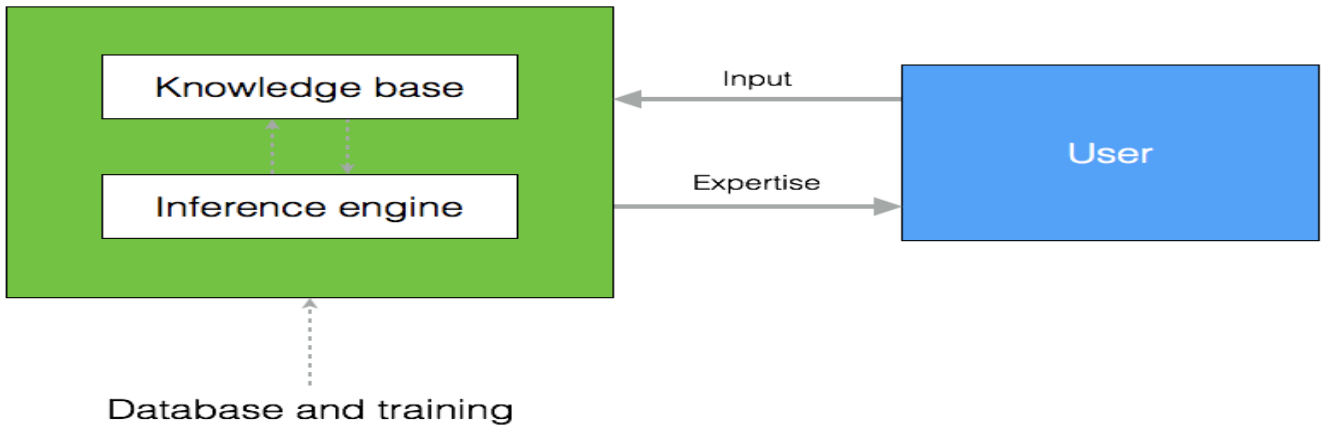
Now that we know how information gets processed, let's see where AI appears in the real world. AI has been used across many industries and it continues to expand rapidly.

Some of the most popular areas include:

- **Computer Vision**: These are the systems that deal with visual data such as images and videos. These systems understand the content and extract insights based on the use case.
- **Natural Language Processing (NLP)**: This field deals with understanding text. We can interact with a machine by typing natural language sentences. Search engines use this extensively to deliver the right search results.

APPLICATIONS OF AI

- **Speech Recognition**: These systems are capable of hearing and understanding spoken words. For example, there are intelligent personal assistants on our smartphones that can understand what we are saying and give relevant information or perform an action based on that.
- **Expert Systems**: These systems use AI techniques to provide advice or make decisions. They usually use databases of expert knowledge areas such as finance, medicine, marketing, and so on to give advice about what to do next



APPLICATIONS OF AI

- **Games**: AI is used extensively in the gaming industry. It is used to design intelligent agents that can compete with humans.
- **Robotics**: Robotic systems actually combine many concepts in AI. These systems are able to perform many different tasks.

➢ Depending on the situation, robots have sensors and actuators that can do different things.

➢ These **sensors can see things in front of them** and measure the temperature, heat, movements, and so on.

➢ They have processors on board that compute various things in real time. They are also capable of adapting to the new environments.

BRANCHES OF AI

It is important to understand the various fields of study within AI so that we can choose the right framework to solve a given real-world problem. Here's a list of topics that are dominant:

- **Machine learning and Pattern recognition**: This is perhaps the most popular form of AI out there.

➢ We design and develop software that can learn from data. Based on these learning models, we perform predictions on unknown data.

➢ One of the main constraints here is that these programs are limited to the power of the data. If the dataset is small, then the learning models would be limited as well. Let's see what a typical machine learning system looks like:

BRANCHES OF AI

- **Logic-based AI**: Mathematical logic is used to execute computer programs in logic-based AI.
  - A program written in logic-based AI is basically a set of statements in logical form that express facts and rules about a particular problem domain.
  - This is used extensively in pattern matching, language parsing, semantic analysis, and so on.
- **Search**: The Search techniques are used extensively in AI programs. These programs examine a large number of possibilities and then pick the most optimal path.
  - For example, this is used a lot in strategy games such as Chess, networking, resource allocation, scheduling, and so on.

BRANCHES OF AI

- **Knowledge representation**: The facts about the world around us need to be represented in some way for a system to make sense of them. The languages of mathematical logic are frequently used here. Such as; **Google Assistance**
- **Planning**: This field deals with optimal planning that gives us maximum returns with minimal costs.

➢ These software programs start with facts about the particular situation and a statement of a goal.

➢ These programs are also aware of the facts of the world, so that they know what the rules are. From this information, they generate the most optimal plan to achieve the goal.

BRANCHES OF AI

Heuristics: A heuristic is a technique used to solve a given problem that's practical and useful in solving the problem in the short term, but not guaranteed to be optimal.

- This is more like an educated guess on what approach we should take to solve a problem.
- In AI, we frequently encounter situations where we cannot check every single possibility to pick the best option. **Like Indexing.**
- So we need to use heuristics to achieve the goal. They are used extensively in AI fields such as robotics, search engines, and so on.

BRANCHES OF AI

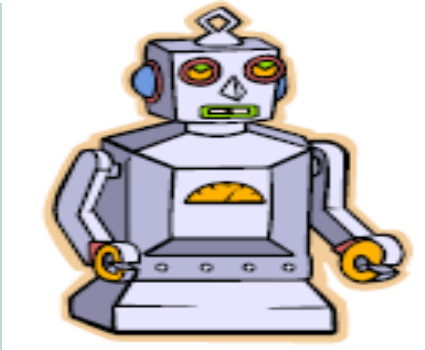
- **Genetic programming**: Genetic programming is a way to get programs to solve a task, by mating programs and selecting the fittest.
- The programs are encoded as a set of genes, using an algorithm to get a program that is able to perform the given task really well.

GOALS OF AI

Systems that think like humans

Systems that Think rationally

Systems that act like humans



Systems that act rationally

Thinking Humanly: Cognitive Science

- Effort to make computer think; i.e. the machine with minds, in the **full and literal sense**.
- Focus is not just on behavior and I/O, but looks at reasoning process
- Computational model as to how result were obtained.

Goal is not just to produce human-like behavior, but **to produce a sequence of steps of the reasoning process**, similar to the steps followed by a human in solving the same task.

Acting Humanly: Turing Test

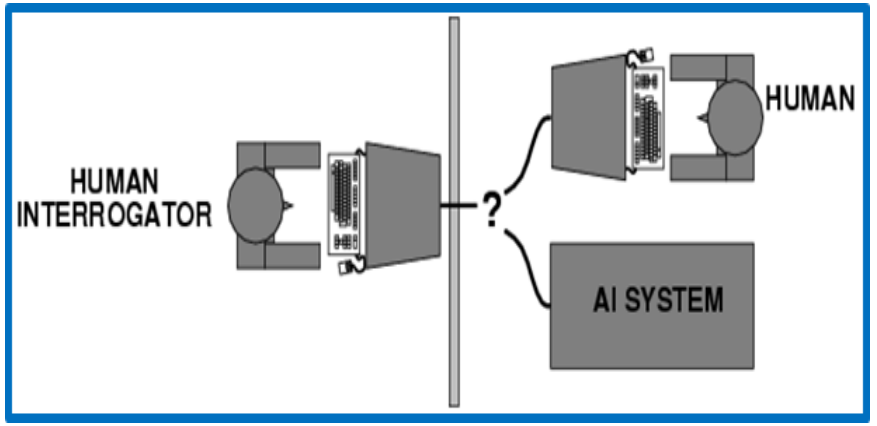
- Art of creating machines that perform functions requiring intelligence when perform by people
- Focus is on actions, and not intelligent behavior centered around representation of the world.
- Is not concerned with how the get result but to the similarity to what human results are

Goal is to develop systems that are human-like

EXAMPLE: TURING TEST,1950

Includes physical interactions with environment

- speech recognition
- computer vision
- robotics



Turing's predictions

- By 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes
- Anticipated all major arguments against AI in following 50 years
- Suggested major components of AI: knowledge representation, reasoning, language understanding, learning

Problem: not **reproducible, constructive, or amenable to mathematical analysis**

Thinking Rationally: Laws of Thought

- Study of mental faculties through the use of computational models; i.e. study of the computations that make it **possible to perceive , reason, and act.**
- Focus is on inference mechanism that are **provably correct and guarantee an optimal solution.**
- Develop systems of representation to allow inference to be like **"Socrates is a man. All men are mortal. Therefore, Socrates is mortal."**

Goal is to formalize the reasoning process as a system of logical rules and procedures for inference.

The issues is, not all problem can be solved just by reasoning and inferences.

Defining Intelligence Using Turing Test

- The legendary **computer scientist and mathematician, *Alan Turing***, proposed the Turing Test to provide a definition of intelligence. It is a test to see if a computer can learn to mimic(follow) human behavior.
- He defined intelligent behavior as the ability to achieve human-level intelligence during a conversation.
- This performance should be sufficient to trick an interrogator into thinking that the answers are coming from a human.

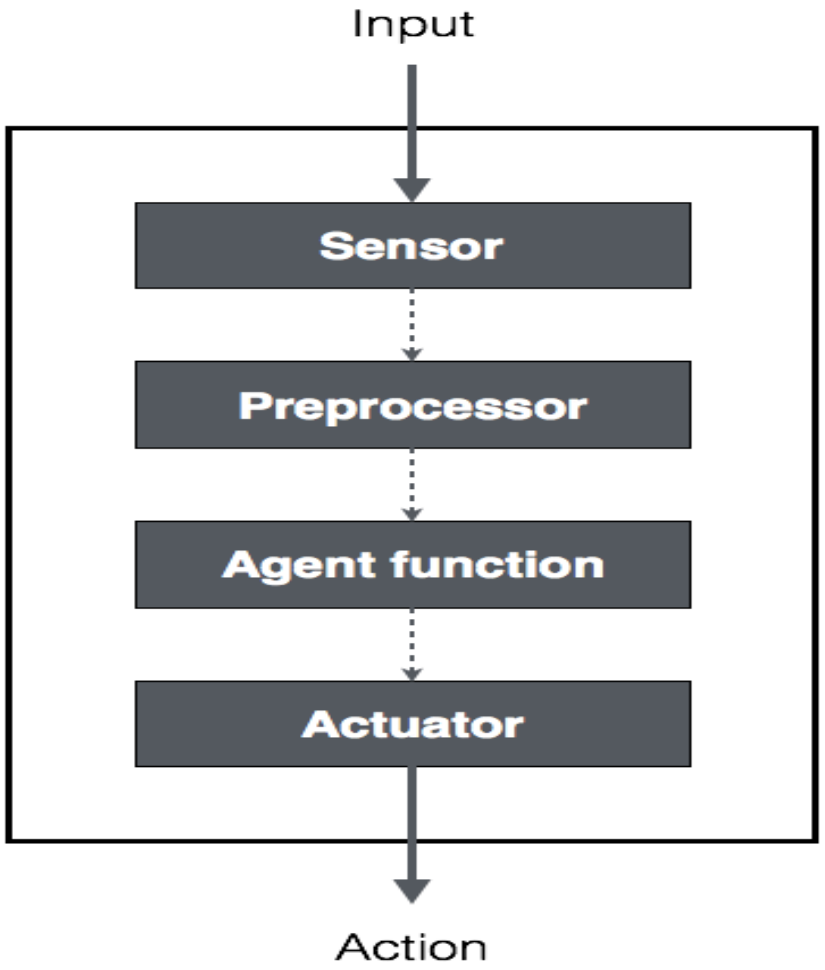
BUILDING RATIONAL AGENTS

A lot of research in AI is focused on building rational agents. What exactly is a rational agent?

- Before that, let us define the word rationality. **Rationality refers to doing the *right thing in a given circumstance*.** This needs to be performed in such a way that there is **maximum benefit to the entity performing the action.**
- An agent is said to act rationally if, given a set of rules, it takes actions to achieve its goals. It just **perceives and acts** according to the information that's available.
- This system is used a lot in AI to design robots when they are sent to navigate unknown terrains.

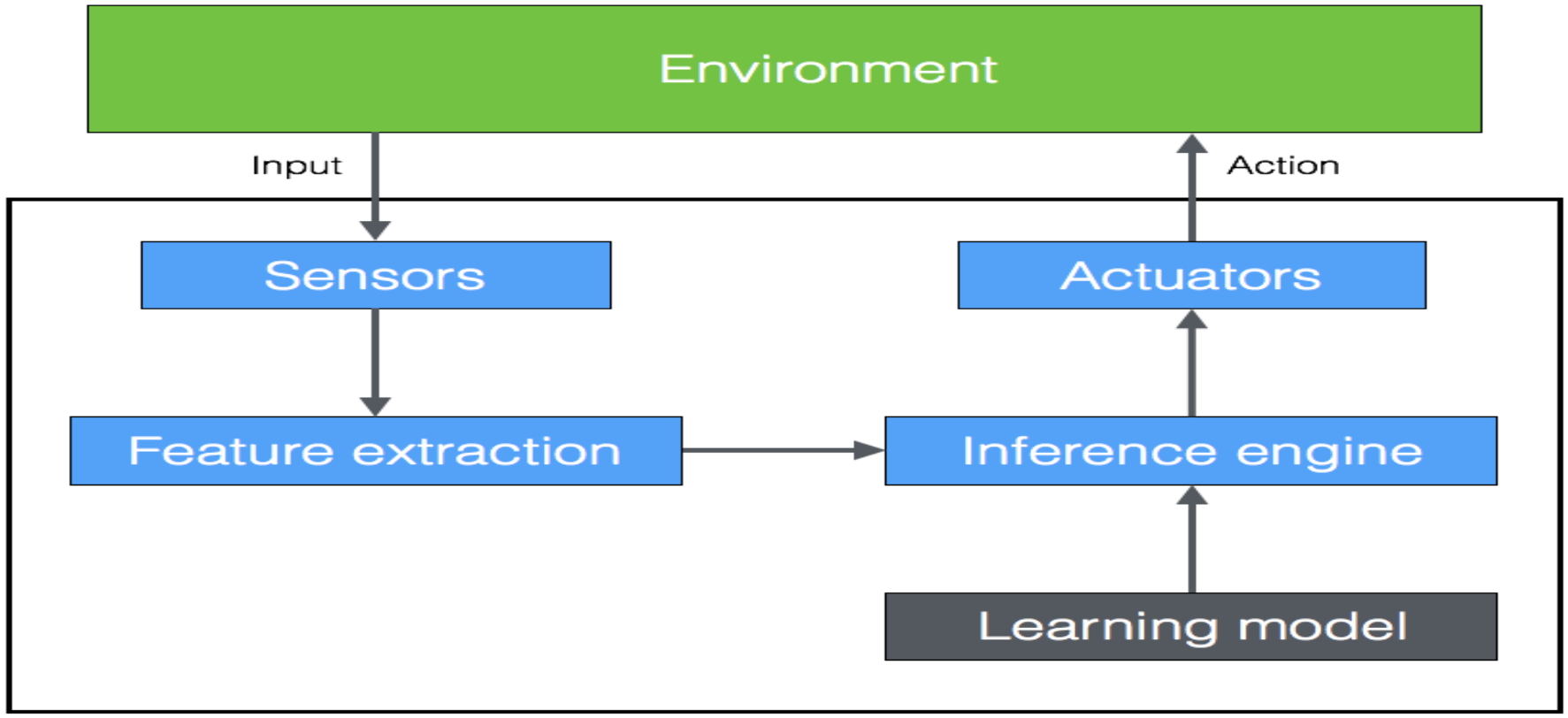
BUILDING RATIONAL AGENTS

Let's see how an input gets converted to action:



BUILDING AN INTELLIGENT AGENT

There are many ways to impart intelligence to an agent. The most commonly used techniques include machine learning, stored knowledge, rules, and so on.



Intelligent agent

BUILDING AN INTELLIGENT AGENT

With machine learning, we want to program our machines to ***use labeled data to solve a given problem.*** By going through the data and the associated labels, the machine learns how to extract patterns and relationships.

In the preceding example, the intelligent agent depends on the learning model to run the inference engine.

- Once the sensor perceives the input, it sends it to the feature extraction block.
- Once the relevant features are extracted, the ***trained inference engine performs a prediction*** based on the learning model.
- This learning model is built using machine learning.
- The inference engine then *takes a decision and sends it to the actuator*, which then takes the required action in the real world.

STRONG AI VS. WEAK AI

- AI research aims to create AI that can replicate human intelligence completely.

Strong AI

- refers to a machine that approaches or supersedes human intelligence
  - if it can do typical human tasks
  - if it can apply a wide range of back ground knowledge and
  - if it has some degree of self-consciousness.
- aims to build machine whose overall ability is indistinguishable from that of human being.

Weak AI

- refers to the use of software to study or accomplish specific problem solving or reasoning tasks that do not encompass the full range of human cognitive abilities. e.g. a chess program
- does not achieve self abilities; it is merely an intelligent, a specific problem solver

FOUNDATIONS OF AI

Philosophy	Logic, Methods Of Reasoning, Mind As Physical System, Foundations Of Learning, Language, Rationality.
Mathematics	Formal Representation And Proof, Algorithms, Computation, (Un)decidability, (In)tractability
Probability/ Statistics	Modeling Uncertainty, Learning From Data
Economics	Utility, Decision Theory, Rational Economic Agents
Neuroscience	Neurons As Information Processing Units.
Psychology/ Cognitive Science	How Do People Behave, Perceive, Process Cognitive Information, Represent Knowledge.
Computer Engineering	Building Fast Computers
Control Theory	Design Systems That Maximize An Objective Function Over Time
Linguistics	Knowledge Representation, Grammars

Potted History of AI

- 1943 McCulloch & Pitts: Boolean circuit model of brain
- 1950 Turing's "Computing Machinery and Intelligence"
- 1956 Dartmouth meeting: "Artificial Intelligence" adopted
- 1950s Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
- 1965 Robinson's complete algorithm for logical reasoning
- 1966—73 AI discovers computational complexity
  Neural network research almost disappears
- 1969—79 Early development of knowledge-based systems
- 1980 AI becomes an industry
- 1986 Neural networks return to popularity
- 1987 AI becomes a science
- 1995 The emergence of intelligent agents -- “-bots”
- 2003 Human-level AI back on the agenda

Is AI Important?

- Most important developments of this century
- It will **affect the lives of most individuals** in civilized countries by the end of the century
- And countries leading in the development of AI by then will emerge as **the dominant economic powers of the world**
- Became apparent to many world's leading economic countries (during late 1970's)
  - Japan (Fifth generation)
  - UK (Alvey Project)
  - Canada, Russia, Italy, France, Singapore etc
  - USA (MCC, DARPA, ALV)

- **The future of a county is closely tied to the commitment it is willing to make in funding research programs in AI**

TASK DOMAINS

Mundane Tasks

Perception

-Vision

-Speech

Natural Language

-Understanding

-Generation

-Translation

Commonsense reasoning

Robot control/HRI

Formal Tasks

Games

-Chess

-Backgammon

-Checkers

- Go

Mathematics

-Geometry

-Logic

-Integral Calculus

- Proving properties of programs

Expert Tasks

Engineering

-design

-Fault finding

-Manufacturing planning

Scientific analysis

Financial analysis

Medical diagnosis

Success Stories of AI Agent

- ✓Deep Blue defeated the reigning world chess champion Garry Kasparov in 1997
- ✓Proved a mathematical conjecture (Robbins conjecture) unsolved for decades
- ✓No hands across America (driving autonomously 98% of the time from Pittsburgh to San Diego)
- ✓During the 1991 Gulf War, US forces deployed an AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people
- ✓NASA's on-board autonomous planning program controlled the scheduling of operations for a spacecraft
- ✓Proverb solves crossword puzzles better than most humans

STATE OF THE ART

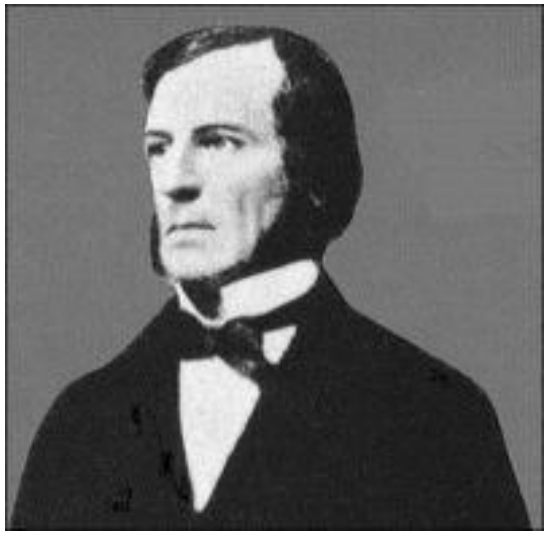
Which of the following can be done at present?

- ☑ Play a decent game of table tennis
- ☑ Drive safely along a curving mountain road
- ☒ Drive safely along Telegraph Avenue
- ☑ Buy a week's worth of groceries on the web
- ☒ Buy a week's worth of groceries at Berkeley Bowl
- ☑ Play a decent game of bridge
- ☒ Discover and prove a new mathematical theorem
- ☒ Design and execute a research program in molecular biology
- ☒ Write an intentionally funny story
- ☑ Give competent legal advice in a specialized area of law
- ☑ Translate spoken English into spoken Swedish in real time
- ☒ Converse successfully with another person for an hour
- ☒ Perform a complex surgical operation
- ☒ Unload any dishwasher and put everything away

SOME KEY PERSONS

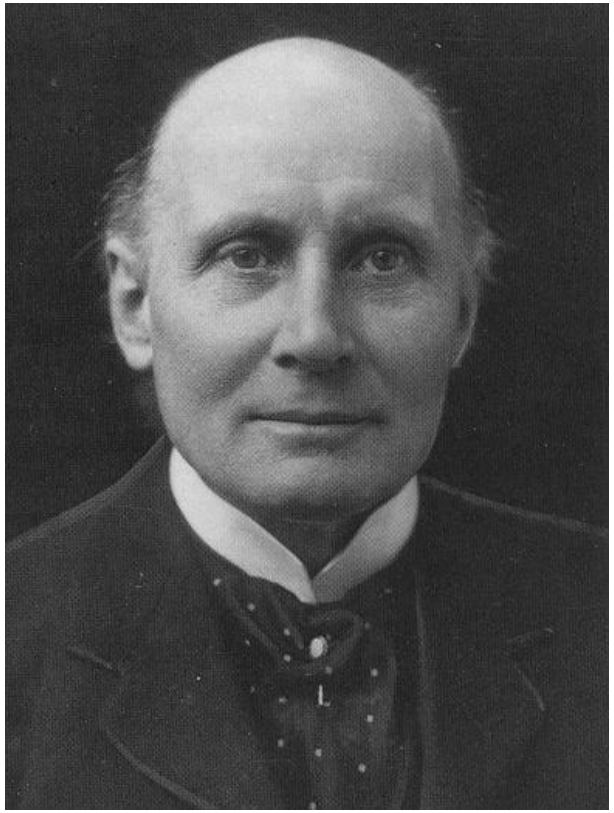
GEORGE BOOLE (1815-1864)

- George Boole was not a computer scientist.
- **Boolean algebra was** developed by him.
- This has become one of the mathematic. foundations of computer science.



ALFRED NORTH WHITEHEAD (1861- 1947)

- Alfred North Whitehead was an English mathematician who became a philosopher.
- He wrote on algebra, logic, foundations of mathematics, philosophy of science, physics, metaphysics, and education.
- He co-authored the epochal **Principia Mathematica** with Bertrand Russell.



BERTRAND ARTHUR WILLIAM RUSSELL, 3RD EARL RUSSELL (1872–1970)

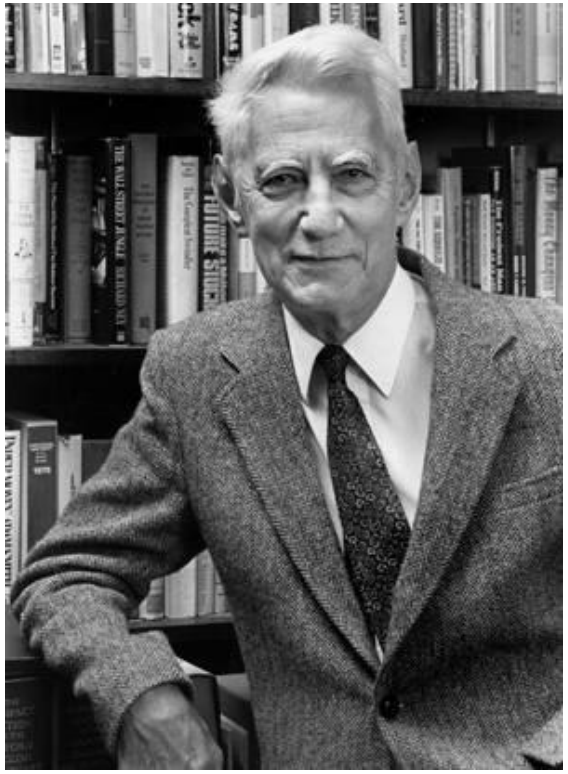
- **Bertrand Arthur William Russell, 3rd Earl Russell was a philosopher,** historian, logician, mathematician, advocate for social reform, and pacifist.
- A prolific writer, he was a populariser of philosophy and a commentator on a large variety of topics.
- He was a prominent anti-war activist, championing free trade between nations and anti-imperialism.
- He wrote the essay On Denoting and was co-author (with Alfred North Whitehead) of ***Principia Mathematica***, an attempt to ground mathematics on the laws of logic.

ALAN TURING (1912-1954)

- Turing is often considered to be the father of modern computer science.
- Turing provided an influential formalization of the concept of the algorithm and computation with the **Turing machine**.
- With the **Turing test,** he made a significant & characteristically provocative contribution to the debate regarding AI: whether it will ever be possible to say that a machine is conscious & can think.

CLAUDE SHANNON(1916-2001)

- **Shannon**, an American electrical engineer and mathematician, was "the father of information theory".
- He is also credited with founding both digital computer and digital circuit design theory in 1937, when, as a 21-year-old master's student at MIT, he wrote a thesis demonstrating that electrical **application of Boolean algebra** could construct and resolve any logical, numerical relationship.

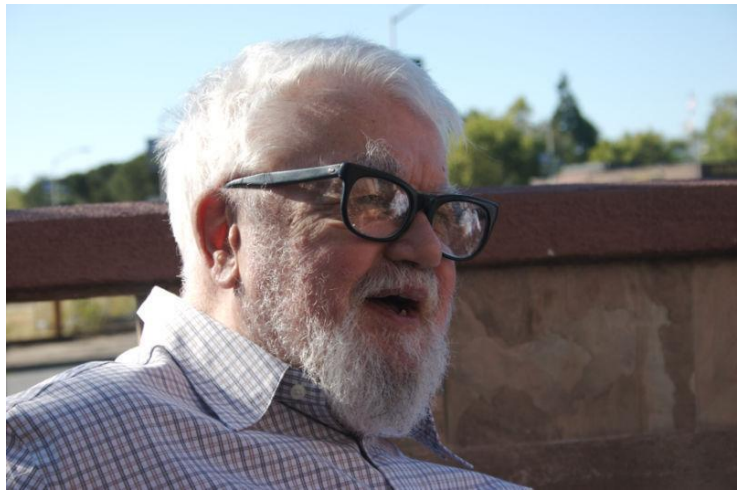


JOHN VON NEUMANN (1903-1957)

- **John von Neumann** was a Hungarian-American mathematician who made major contributions to a vast range of fields including
  - **set theory**
  - functional analysis
  - quantum mechanics
  - ergodic theory
  - economics and game theory
  - **computer science**
- The so called conventional CPU based computer was proposed by him, and he is generally regarded as one of the foremost mathematicians of the 20th century.

JOHN MCCARTHY

- **John McCarthy** (born September 4, 1927, in Boston, Massachusetts), is an American computer scientist & cognitive scientist.
- He received the Turing Award in 1971 for his major contributions to the field of AI.
- He was responsible for the coining of the term "Artificial Intelligence" in his 1955 proposal for the 1956 Dartmouth Conference and is the inventor of the **Lisp programming language.**

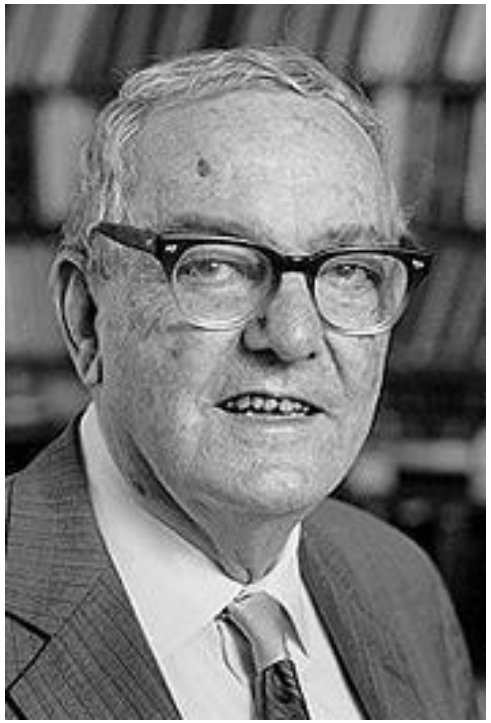


MARVIN LEE MINSKY

- **Marvin Lee Minsky** (born August 9, 1927) is an American cognitive scientist in the field of AI, co-founder of MIT's AI laboratory, & author of several texts on AI & philosophy.
- Minsky won the Turing Award in 1969, the Japan Prize in 1990, the IJCAI Award for Research Excellence in 1991, & the Benjamin Franklin Medal from the Franklin Institute in 2001.

HERBERT ALEXANDER SIMON (1916-2001)

- **Herbert Alexander Simon** was an American political scientist whose research ranged across the fields of cognitive psychology, computer science, public administration, etc.
- Simon was a truly innovative thinker. He was among the founding fathers of several of today's most important scientific domains, including artificial Intelligence, information processing, decision-making, problem-solving, etc.
- He coined the terms bounded rationality & satisfiying, and was the first to analyze the & to propose a preferential attachment mechanism to explain power law distributions.



ALLEN NEWELL (1927-1992)

- **Allen Newell** was a researcher in computer science and cognitive psychology at the RAND corporation and at Carnegie Mellon University's School of Computer Science.
- He contributed to the **Information Processing Language** (1956) and two of the earliest AI programs, the Logic Theory Machine (1956) and **the General Problem Solver** (1957) (with Herbert Simon).
- He was awarded the ACM's A.M. Turing Award along with Herbert Simon in 1975 for their basic contributions to AI & the psychology of human cognition.

EDWARD ALBERT FEIGENBAUM

- **Edward Albert Feigenbaum** (born January 20, 1936) is a computer scientist working in the field of AI.
- He is often called the **"father of expert systems."**
- In his PhD thesis, carried out under the supervision of Herbert Simon, he developed EPAM, one of the first computer models of how people learn.
- He received the ACM Turing Award, jointly with Raj Reddy in 1994 "For pioneering the design and construction of large scale artificial intelligence systems, demonstrating the practical importance & potential commercial impact of artificial intelligence technology".

The END

Questions ??