Artificial Intelligence
LCS 2206
Lecture 1 - Introduction

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Lecture objectives

By the end of this lecture students should be able to:

- Define Artificial Intelligence
- Explain the type of intelligence AI falls under
- Explain the various models of AI
- Explain the concept of rational behaviour as applied to AI
- Explain the limitations of rational behaviour used by AI

What is artificial intelligence?

- There is no clear consensus on the definition of artificial intelligence (AI).
- Notable early contributions to the definition include:
  - ✓The study of mental faculties through the use of computational models (Charniak and McDermott, 1985).
  - ✓A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes (Schalkoff, 1990).
  - ✓The study of how to make computers do things at which, at the moment, people are better (Rich and Knight, 1991).
  - ✓The branch of computer science that is concerned with automation of intelligent behaviour (Luger and Subblefield, 1993).

Interesting!

- Russsell & Norvig: It is concerned with a program that:
  - Thinks like human – demonstrates human-like patterns of thinking steps.
  - Acts like human – Turing test
  - Acts or thinks rationally – logically, and correctly.

❑Clearly, it is a conceptual aspect of machine intelligence.

❖Intelligence demonstrated by machines.

"The science and engineering of making intelligent machines, especially intelligent computer programs"

John McCarthy, 'father of AI', 1956

In a nutshell

- AI refers to the theory and development of computer systems that are able to perform tasks normally requiring human intelligence.
  - ➢ It is a system's ability to correctly interpret external input data, learn from the data, and use that knowledge to achieve specific goals and tasks through flexible adaptation.

❑ AI is a conceptual aspect of machine intelligence – that is intelligence demonstrated by machines.

AI and intelligence

- AI programs to model aspects of intelligent behavior.
  - Thinking flexibly, decision-making, gathering data through many senses, empathy, etc.
- Other mental activities involved include:
  - Understanding
  - Perception
  - Consciousness
  - Creativity
  - Problem-solving
  - Using language
  - Speech recognition, and
  - Translations between languages

Composition of AI

- AI is an applied science that is implemented as an intersection between mathematics (particularly data analytics), biology and computer science.
  - ➢ It involves programming computers to understand human or other intelligence, although AI does not have to confine itself to methods that are biologically observable.
- AI emphasizes the creation of intelligent machines that act and react like humans.
  - ➢ It makes it possible for machines to learn from experience, adjust to new inputs and perform human-like tasks.
- The AI field draws upon other fields, such as information engineering, mathematics, psychology, linguistics, philosophy, and many others.

AI in summary

- In summary, AI is:
  - ✓Synthetic intelligence – Program synthesis involves automatically generating programs.
  - ✓A type of computer technology in terms of a computer system that performs some intellectual function
  - ✓An applied science
  - ✓A branch of computer science
  - ✓An emerging technology
  - ✓An academic discipline

- ❑ **Generally AI uses logical/mathematical/Reasoning intelligence**
  - ➢ Reasoning intelligence is the ability to calculate, quantify, consider propositions and hypotheses, and to carry out intelligent operations so as to automatically and statically verifying correctness and inferring properties of programs.

Levels of AI

- In the domain of AI, there are three different levels.
  - ✓Weak artificial intelligence
  - ✓Strong artificial intelligence
  - ✓superintelligence

➢Weak AI is the AI technique that can build systems that are able to behave in the same manner as humans but do not have the aim of thinking as humans think.

- Weak AI is also sometimes called Narrow AI.
- It includes work that is limited to a specific or narrow area.
- It develops intelligent machines meant to meet certain tasks.

Levels of AI…

- Strong AI is AI that develops intelligent machines that can successfully perform any intellectual task that a human being can.
  - Strong AI is also sometimes called True AI or artificial general intelligence (AGI)
  - General AI develops intelligent machines that are designed to reason solely like humans
  - It includes work that looks to genuinely imitate a human – and that could potentially even explain the way humans think.
  - Its application is common in science fiction and robotics.

Levels of AI

- Superintelligence – is artificial intelligence far surpassing that of the brightest and most gifted human minds.
  - This is currently considered a hypothetical AI.
  - Superintelligence is expected to be a rapid outcome of creating artificial general intelligence, and to be achieved due to recursive self-improvement.

Advantages of AI

- AI achieves a low error rate compared to humans.
- AI helps overcome the limitations that humans have.
- AI systems make rational decisions, with less or no mistakes.
- AI facilitates prediction of future actions and conditions e.g. rainfall, faults, etc.
- AI facilitates treatment and management of human health e.g. robotics in radiosurgery, etc.
- AI facilitate faster decision making.
- Used to build intelligent public utilities, such as intelligent self-driving cars, smart does, smart gates, etc.

Garry Kasparov vs Deep Blue, 11 May 1997

Disadvantages of AI

- AI based systems involve cost incurred in the maintenance and repair.
- Application of AI involves adherence to ethics and moral values.
- The storage, access, and retrieval of stored data in AI systems is not as effective as in case of the human brain.
- AI systems are a threat to human being by causing unemployment.
- AI self-learning systems are not yet fully autonomous.
- AI domain can be misused if it is in the wrong hands to cause destruction – systems may be programmed to do wrong things, or for mass destruction.
- AI systems can be easily fooled.

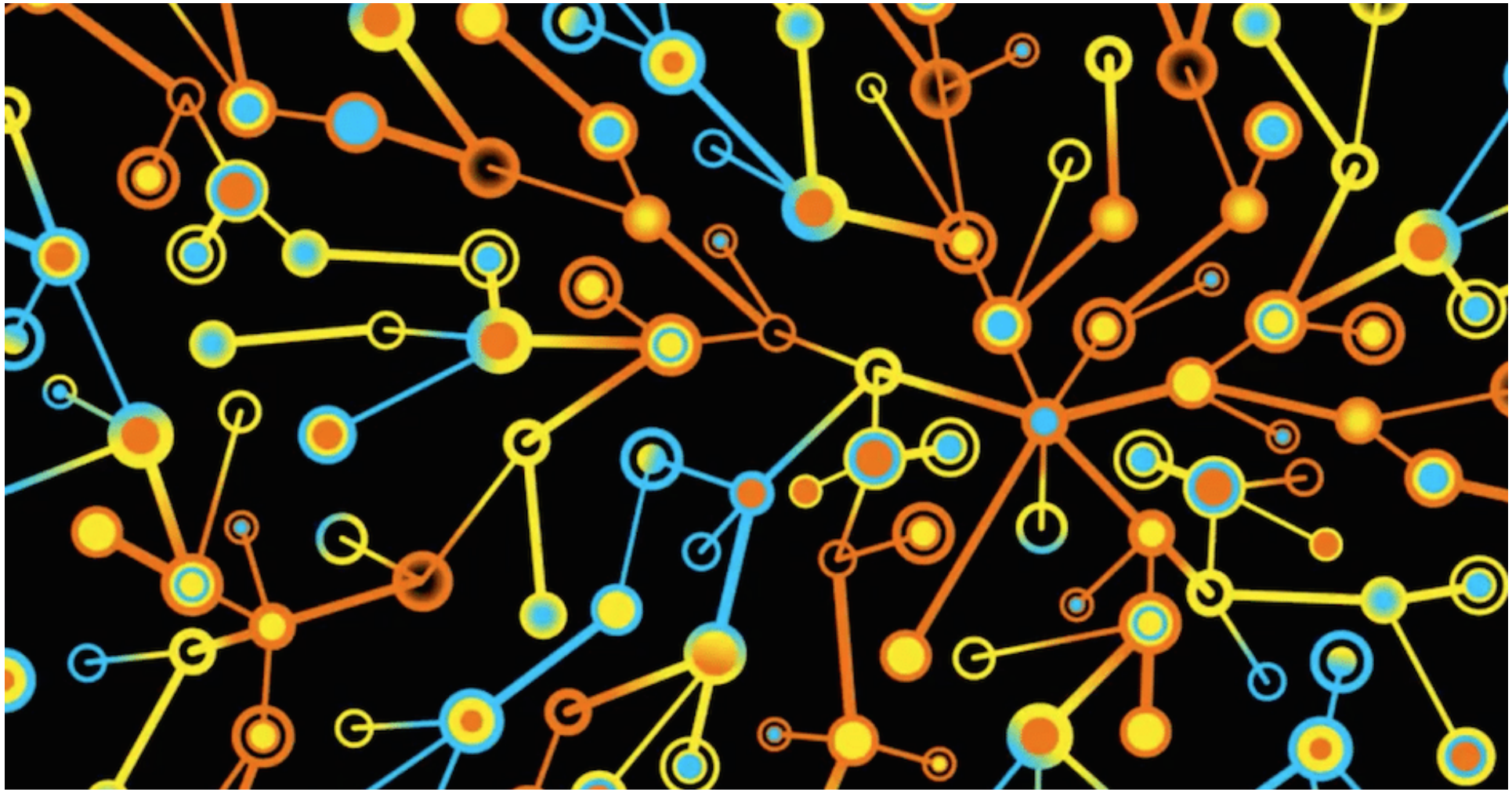
Common problems where AI is handy

- Deduction, reasoning, problem solving, such as;
  - Theorem-provers, solve puzzles, play board games
- Knowledge representation, such as;
  - Expert systems
- Automated planning and scheduling
- Machine Learning and Perception, such as;
  - detecting credit card fraud, stock market analysis, classifying DNA sequences, speech and handwriting recognition, object and facial recognition in computer vision

Common problems where AI solution is handy

- Natural language processing, such as;
  - ✓Natural Language Understanding
  - ✓Speech Understanding
  - ✓Machine Translation
  - ✓Information retrieval and text mining
- Motion and manipulation, such as;
  - ✓Robotics handle object manipulation and navigation, with sub-problems of localization (knowing where you are), mapping (learning what is around you) and motion planning (figuring out how to get there)
- Social and business intelligence, such as;
  - ✓Social and customer behaviour modelling
- Etc, etc.

Social and business intelligence modelling



Classification of AI systems

- Derived from the above types of AI systems, there are three classes of AI systems: analytical, human-inspired, and humanized AI systems.
  - **Analytical AI systems** – have only characteristics consistent with cognitive intelligence, generate cognitive representation of the world, and use learning based on past experience to inform future decisions.
  - **Human-inspired AI systems** – have elements from cognitive as well as emotional intelligence and understanding.
  - **Humanized AI systems** – show characteristics of all types of competencies (including cognitive, emotional, and social intelligence), and are self-conscious and self-aware in interactions with others.

Categories of AI Systems

- Within the domain of AI, there are different levels.
- There are broadly two parameters for determining the types of AI systems:
  a) Based on output
  b) Based on functionality

a) Based on output

- They include:
  - ✓Analytical AI
  - ✓Functional AI
  - ✓superintelligence

Based on output

- **Analytic AI systems** – systems that scan large amounts of data for dependencies and patterns to ultimately produce recommendations or provide insights, thus contributing to data-driven decision-making
  - Examples include **Sentiment analysis** and supplier risk assessment system.
- **Functional AI systems** – like analytic AI, it also scans huge amounts of data and searches for patterns and dependencies in it. However, instead of giving recommendations, functional AI takes actions.
  - For examples, being the part of the IoT cloud, it can spot a machine-breakdown pattern in the sensor data received from a certain machine, and trigger a command to turn this machine off.
  - Another example: robots that package bottles in beverages factories.

Based on output

- **Interactive AI systems** – automate communication without compromising on interactivity.
  - ➢Example is a ***chatbot*** and a ***smart personal assistant*** whose abilities can vary from answering pre-built questions to understanding the conversation context.
- **Text AI systems** – uses semantic search and natural language processing to build semantic maps and recognize synonyms to understand the context of communication, facilitating ***text recognition***, ***speech-to-text conversion, machine translation***, and ***content generation*** capabilities.
  - ➢For example, powering an internal corporate knowledge base.
  - ❖Instead of search by keywords, it can find the document containing the most relevant answer even if the document doesn't have full keywords.

Based on output

- **Visual AI systems** – AI that can identify, recognize, classify and sort objects or convert images and videos into insights.
  - ➢Example is a computer system that helps an insurer to estimate damage based on damaged car photos or a machine that grades apples based on their color and size.
  - ❖This type of AI covers ***computer vision*** or ***augmented reality*** fields.

b) Based on functionality

- Grouping AI basing on system functionality, there are four types of AI systems, also known as levels of AI systems, including:
  - ✓Reactive systems
  - ✓Limited memory systems
  - ✓Theory of mind systems
  - ✓Self-aware systems

Based on functionality

- **Reactive systems** – are purely reactive, and have the ability neither to form memories nor to use past experiences to inform current decisions.
  - E.g. Deep Blue, IBM's chess-playing supercomputer, which beat international grandmaster Garry Kasparov in the 1997, is the perfect example of this type of this.
    - Deep Blue could identify the pieces on a chess board and know how each moves.
    - It could make predictions about what moves might be next for it and its opponent.
    - And it could then choose the most optimal moves from among the possibilities.

Based on functionality…

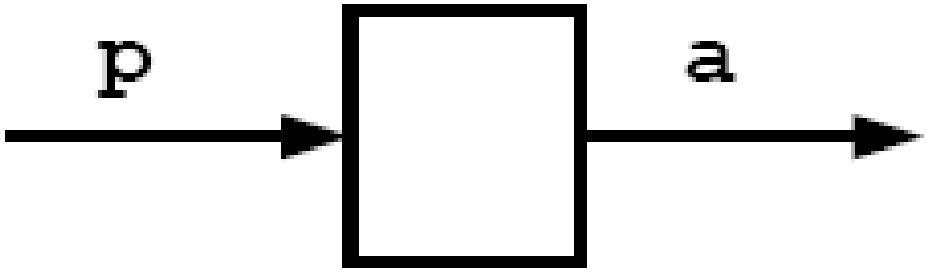
- **Reactive AI systems** – don't have any concept of the past, nor any memory of what has happened before, and ignores everything before the present moment.
  - All it does is look at the problem as it stands right now, and choose from possible solutions.
- This type of AI involves the computer perceiving the world directly and acting on what it sees.
- They behave exactly the same way every time they encounter the same situation.

Based on functionality

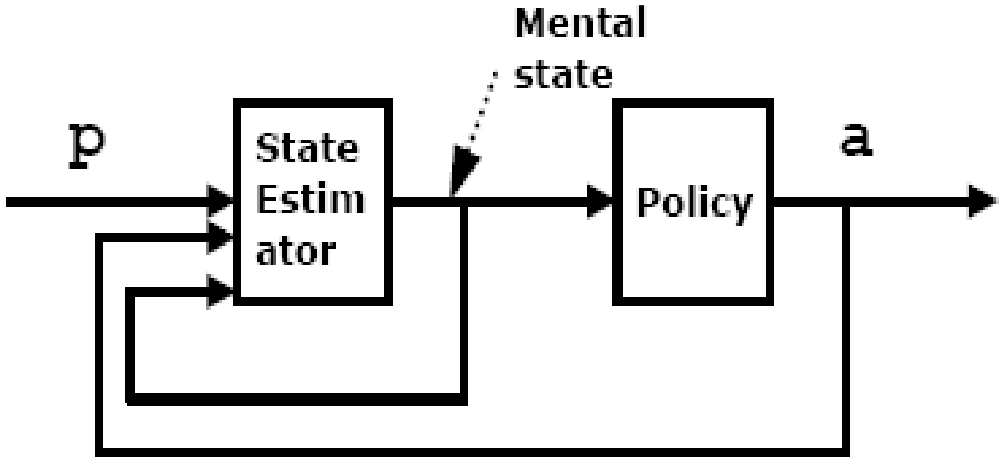
- Limited AI systems – look into the past, identify specific objects and monitor them over time.
  - ➢ Examples include self driving cars
- The pieces of information about the past are only transient.
  - ➢In the above example, they aren't saved as part of the car's library of experience where it can learn from
    - ○The same way a human driver compiles experience over the years as a driver.

Reactive AI agents vs Limited memory AI Agents

- Reactive agents
  - No memory



- Agents with memory
  - Limited memory



Based on functionality

- Theory of mind systems – systems with advanced representations about the world, including about other agents or entities in the world
  - They understanding that people, creatures and objects in the world can have thoughts and emotions that affect their own behavior.
    - So that they can adjust their behavior accordingly.
    - An example of this is a socially assistive robot like Ballie.
  - Without understanding the system's and its opponents' possible motives and intentions, and its environment, building such a system is at best difficult, and at worst impossible.

Based on functionality

- **Self-ware AI systems** – have consciousness and can form representations about themselves.
  - ➢ This is an extension of “theory of mind” systems.
  - ➢ It is expected to be the next phase of AI.
- These systems are aware of themselves, know about their internal states, and are able to predict feelings of others.
  - ➢ While we are probably far from creating systems that are self-aware, we should focus on understanding memory, learning and the ability to base decisions on past experiences.
    - This is crucial if we want to design or evolve systems that are more than exceptional at classifying what they see in front of them.

AI Subfields

- AI can be divided into many subfields:
- **Machine learning** - this automates analytical model building by using methods from neural networks, statistics, operations research and physics to find hidden insights in data without explicitly being programmed for where to look or what to conclude.
- **Neural network** - is a machine learning method that is made up of interconnected units (like neurons) that processes information by responding to external inputs, relaying information between each unit.
  - The process requires multiple passes at the data to find connections and derive meaning from undefined data.

AI Subfields

- **Deep learning** - is a machine learning method that uses neural networks with many layers of processing units, taking advantage of advances in computing power and improved training techniques to learn complex patterns in large amounts of data.
  - Common applications include image and speech recognition.
  - A new emergence from it is End-to-end AI where the system considers a problem from beginning to its end and delivers a complete functional solution, usually without needing to obtain anything from a third party.
- **Cognitive computing** - is a subfield of AI that strives for a natural, human-like interaction with machines.
  - The goal is for a machine to simulate human processes through ability to interpret images and speech, and then itself speak coherently in response.

AI Subfields

- **Computer vision** - relies on pattern recognition and deep learning to recognize what's in a picture or video.
  - Computer vision systems can process, analyze and understand images, and can capture images or videos in real time and interpret their surroundings.
- **Natural language processing** (NLP) - is the ability of computers to analyze, understand and generate human language, including speech.
  - The next stage of NLP is natural language interaction, which allows humans to communicate with computers using normal, everyday language to perform tasks.

AI paradigms

- AI paradigm refers to the approach in terms of the concept of intelligence and methodology on which intelligent computer systems are developed and operated.
- There is no established unifying theory or paradigm that guides AI research. Researchers disagree about many issues.
- The popular AI paradigms currently is use include:
  - Cybernetics and brain simulations - a transdisciplinary approach for exploring regulatory systems: their structures, constraints, and possibilities.
  - Symbolic – collection of all methods in artificial intelligence research that are based on high-level "symbolic" representations of problems, logic and search, where all steps are based on symbolic human readable representations of the problem that use logic and search to solve problem.

AI paradigms

- Cognitic simulations - AI technologies are required for a computer system to build cognitive models that mimic human thought processes
- Embodied intelligence – the computational approach to the design and understanding of intelligent behavior in embodied and situated agents through the consideration of the strict coupling between the agent and its environment (situatedness), mediated by the constraints of the agent's own body, perceptual and motor system, and brain (embodiment).
- Computational intelligence – involves design, application and development of biologically and linguistically motivated systems.
- Statistical learning – this deals with the problem of finding a predictive function based on data.

AI paradigms

- Anti-logic or scruffy – solving difficult problems in vision and natural language.
- Knowledge-based – AI implementation that reasons using and based on a knowledge base to solve complex problems.

Commonly AI supported technologies

- Automating IOT models with AI will allow us to use more of it.
  - ➢ This generates massive amounts of data, AI bases on their analyzes.

…. Where everything is intelligent

Commonly AI supported technologies…

- **Graphical processing units** - provide intelligent computing power that's required for iterative processing.
- **Advanced algorithms -** are being developed and combined in new ways to analyze more data faster and at multiple levels. This intelligent processing is key to identifying and predicting rare events, understanding complex systems and optimizing unique scenarios.
- **Application processing interfaces (APIs) -** are portable packages of code that make it possible to add AI functionality to existing products and software packages. They can add image recognition capabilities to home security systems and Q&A capabilities that describe data, create captions and headlines, or call out interesting patterns and insights in data.

AI and Models

- AI involves creation of models.
  - A model is a representation of a person or thing, often on a smaller scale, that can be used as an example for future similar developments.
- An AI system model is based on four parameters: thinking, behavior, humanity, rationality.
  - Thinking – reasoning on available information and evidence, based on assumptions and with a purpose
  - Behavior – actions and mannerisms made by the artificial entities in conjunction with themselves or their environment
  - Human – quality of being humane and benevolent.
  - Rationality - quality of being based on or in accordance with reasoning or logic.

1. Systems that think like humans

- Also referred to as **“computational model of human thought”,** or **Cognitive Modelling.**
  - ➢Systems that operate internally the way humans do.
    - They simulate human thought as observed from ‘inside’.
- Here, computers are associated with cognitive science
  - ➢It involves the automation of activities that we associate with human thinking, such as decision-making, problem solving, and learning.

Systems that think like humans…

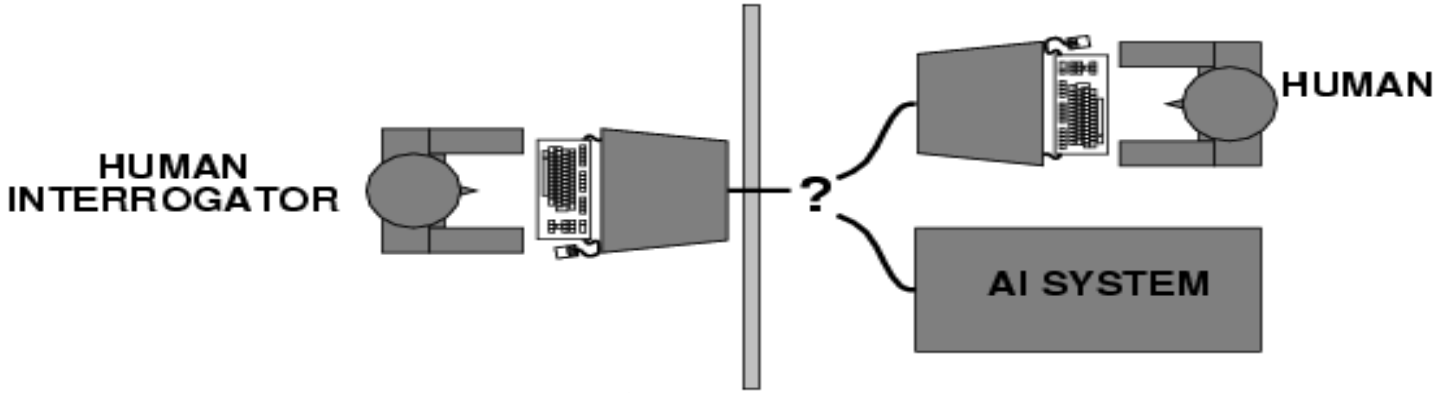
- Major application areas are:
  - **Computer vision** – scientific field that deals with how computers can be made to gain high-level understanding from digital images or videos.
    - Concerned with how to perceive objects through seeing.
  - **Robotics** – branch of computer science and engineering that deals with the design, construction, operation, and application of robots.
    - Concerned with how to move objects – controls in robots, sensory feedback, and information processing.

2. Systems that act like humans

- Also referred to as **“computational model of human behaviour”**
  - Programs that behave (externally) like humans.
  - Originated as an idea from Allan Turing in 1950.
  - The Turing Test is used to verify this.
- Aim of the intelligent behavior is to achieve human-level performance in all cognitive tasks

Turing Test

- The Turing Test is:
  - ➢This is when a human questioner, via a teletype communication, cannot differentiate where it is a computer or a human answering a question
    - ○ Because the computer is behaving as intelligently as a human being.
  - ➢The Turing test can check a machine's ability to exhibit intelligent behavior equivalent to human intelligence



Systems that act like humans…

- Applications of systems that act like humans include:
  - ✓ **Natural language processing** – concerned with the interactions between computers and human languages to process and analyze large amounts of natural language data.
    - ➢To facilitate system communication with humans
  - ✓ **Knowledge representation** – representing information which can solve complex tasks, such as diagnosing a medical condition or having a dialog in a natural language.
    - ➢To store information effectively & efficiently.
  - ✓**Automated reasoning** - an area of cognitive science and metalogic dedicated to understanding different aspects of reasoning.
    - ➢To retrieve & answer questions using the stored information

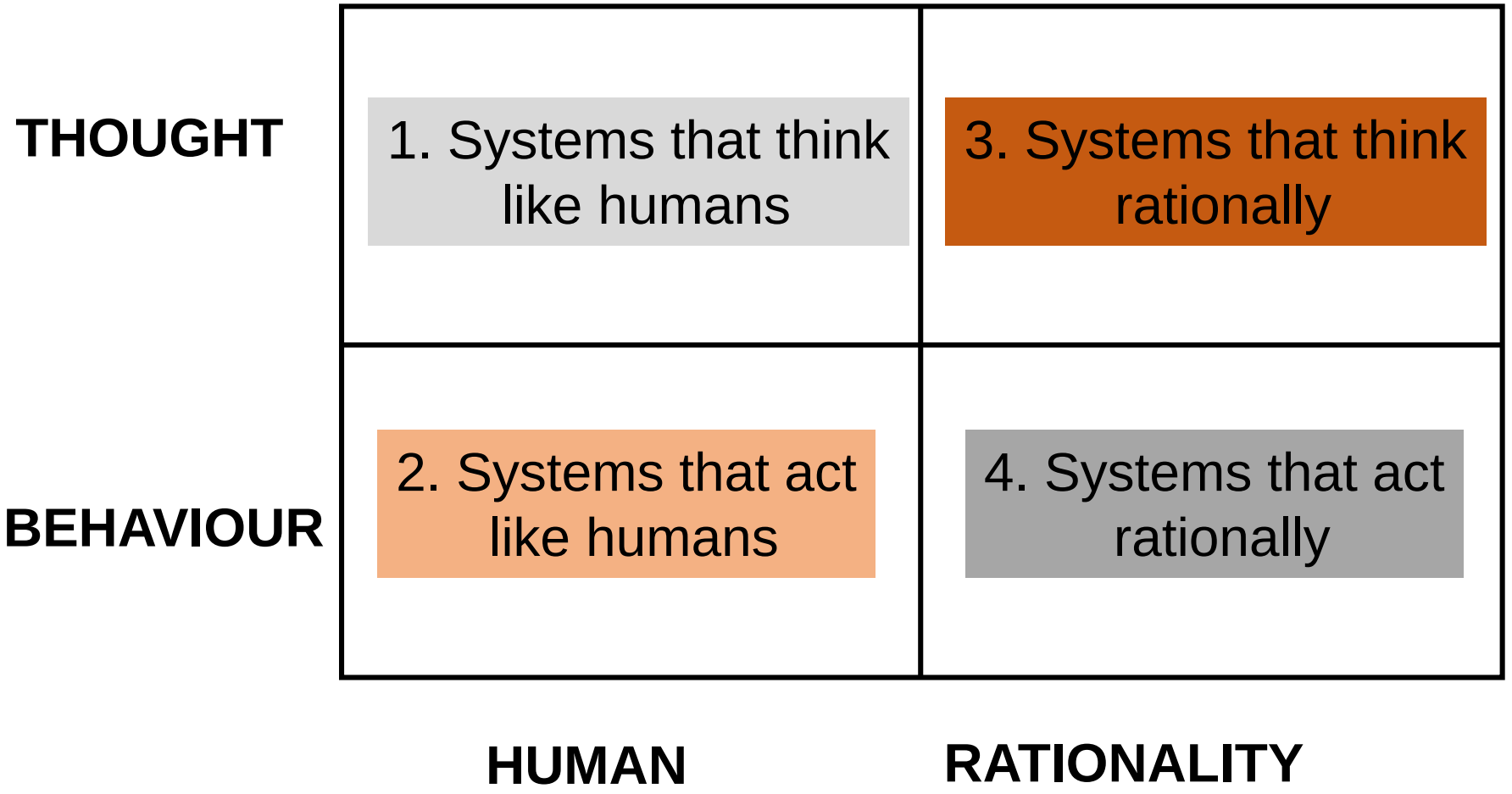
3. Systems that think ‘rationally’

- This involves simulating mental faculties through the use of computational models.
  - ➢ It makes it possible to perceive, reason, and act.
  - ➢ Involves system thinking in terms of logic.
- Since logic can’t express everything (e.g. uncertainty), logical approach is often infeasible in terms of computation time.
- An example is **General Problem Solver (GPS),** an early computer program that attempted to model human thinking. The developers were not so much interested in whether or not GPS solved problems correctly.

4. Systems that act rationally

- Such a system is also referred to as a “Rational agent”
  - ➢ Rational behavior involves doing the expected right things rightly to maximum achievement of a goal, given available information.
    - ○ Here, giving answers to questions is ‘acting’.
- These systems don’t care whether a system:
  - ✓ replicates human thought processes
  - ✓ makes the same decisions as humans
  - ✓ uses purely logical reasoning

AI models


THOUGHT
BEHAVIOUR
1. Systems that think like humans
3. Systems that think rationally
2. Systems that act like humans
4. Systems that act rationally
HUMAN
RATIONALITY

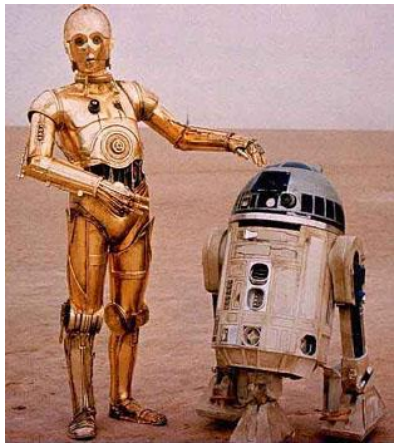
Models in Summary

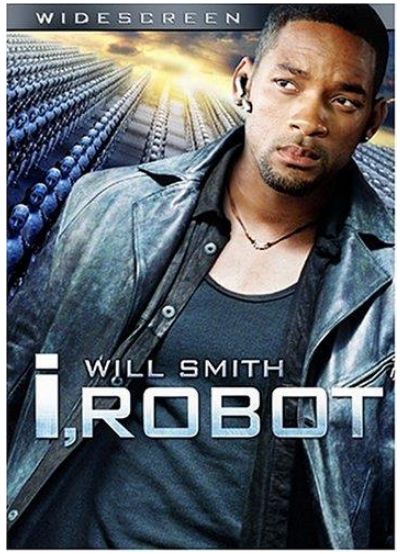
- Modern AI focuses on the last definition
  - ➢ Success is judged by how well the agent performs
    - Modern methods are inspired by cognitive- & neuro-science (how people should think and then act).
  - ➢ Computational systems that behave not only intelligently, but also rationally.

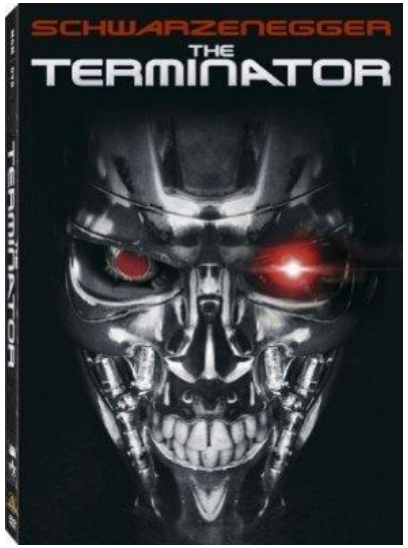
General applications of AI

- Converting text to voice e.g. using **Speechelo Pro**.
- Autonomous planning and scheduling of tasks aboard a spacecraft
- Games, such as Deep blue beating Gary Kasparov in a chess match
- Steering a driver-less car
- Understanding language
- Robotic assistants in surgery
- Monitoring trade in the stock market
- Smart fridges
- Smart doors
- etc, etc, …

Artificial Intelligence in movies





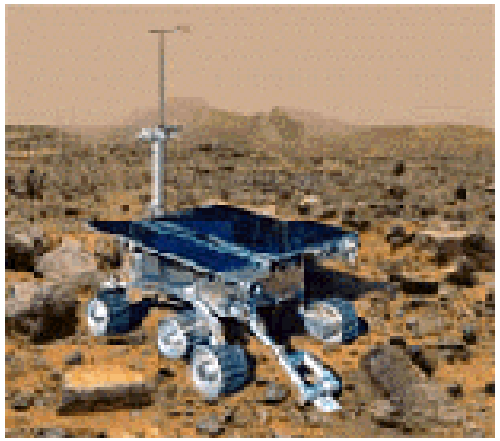


General applications of AI…

- ✓Intelligent user interfaces
- ✓Search Engines
- ✓Spell/grammar checkers
- ✓Context sensitive help systems
- ✓Medical diagnosis systems
- ✓Regulating/Controlling hardware devices and processes (e.g. in automobiles)
- ✓Voice/image recognition
- ✓Error detection/correction in electronic communications
- ✓Program verification / compiler and programming language design
- ✓Web search engines / Web spiders
- ✓Web personalization and Recommender systems (collaborative/content filtering)
- ✓Customer relationship management
- ✓Credit card verification in e-commerce / fraud detection
- ✓Data mining and knowledge discovery in databases
- ✓etc, etc…

The Vast applications of AI

Labor



Science

Appliances

Google

YAHOO!

Search engines

Medicine/
Diagnosis

What else?

For-profit companies that use AI.

AI development tools

- Common open-source development tools for AI systems include:
  - ✓OpenAIR - is a message routing and communication protocol for **artificial intelligence** systems that has been gaining in popularity in recent years.
    - ➢openAIR is a free implementation of the **OpenAIR** (**Artificial Intelligence** Routing) protocol, first proposed by CMLabs
  - ✓OpenCog - A Platform for the Decentralized AI Economy SingularityNET, an OpenCog-affiliated project, is a free and open market for AI technologies, built on smart contracts, and oriented toward the emergence of powerful decentralized general intelligence.

AI development tools

- ✓OpenIRIS - open source version of IRIS, a semantic desktop that enables users to create a "personal map" across their office-related information objects.
  - ➢The name IRIS is an acronym for "Integrate.
- ✓Jupyter Notebook - an open-source software library for dataflow programming across a range of tasks.
  - ➢It is a symbolic math library, and is also used for machine learning applications such as neural networks.
- ✓Others include: RapidMiner, TensorFlow, etc…

Thank you.