COMP338: **ARTIFICIAL INTELLIGENCE**

Introduction to Artificial Intelligence

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Logistics

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- Textbooks
  - Artificial Intelligence: A Modern Approach 3rd edition. Russel and Norvig, Pearson, 2010
  - Artificial Intelligence A Guide to Intelligent Systems 2nd edition. Michael Negnevitsky, Addison Wesley, 2004
  - Artificial Intelligence Structures and Strategies for Complex Problem Solving 5th edition. George F Luger & W.   A. Stubblefield, Addison-Wesley, 2005

Topics to be covered

Week #	Course Content
	Topic
1	Introduction to AI
2	Intelligent Agents
3, 4	Problem Solving and (uniformed) Search
5	Heuristic (informed) search
6	Games and Adversarial search
7, 8	Machine Learning
9, 10, 11	NLP
12, 13	Knowledge and Reasoning

Learning outcomes

Upon successful completion of this course, the student will be able to:

- Knowledge and understanding
  - Identify the different application areas of Artificial Intelligence
  - Understand the fundamental concepts of artificial intelligence, techniques, and mechanisms
  - Understand basic techniques and methodologies in knowledge representation, automated reasoning (search techniques), and different types of agents
- Intellectual/Cognitive skills
  - Identify problems that can be solved using AI techniques and which AI method to be applied to solve problems at hand
  - Formalise a given problem, in programming languages, using different AI methods and techniques

Learning outcomes

- Subject specific and practical skills
  - Implement basic AI algorithms
  - Design and conduct empirical evaluations of different AI algorithms

- General and transferable skills
  - Communication and oral skills by discussing matters related to AI techniques
  - Working in groups to design and implement solutions of AI related problems
  - State conclusions that the evaluations and comparisons of different algorithms support

ARTIFICIAL INTELLIGENCE

What is Artificial Intelligence?

- AI is one of the newest fields in science and engineering

- Work started to develop this field soon after World War II, and the name was coined in 1956

- Along with molecular biology, AI is regularly cited as the "field I would most like to be in" by scientists in other disciplines

What is Artificial Intelligence?

- Imitate the human thinking and behavior through computers

- Reflect our abilities to make decision through computer programs

- The field of computer science that aims at simulating the human performance to make computers reason in a manner that is similar to humans
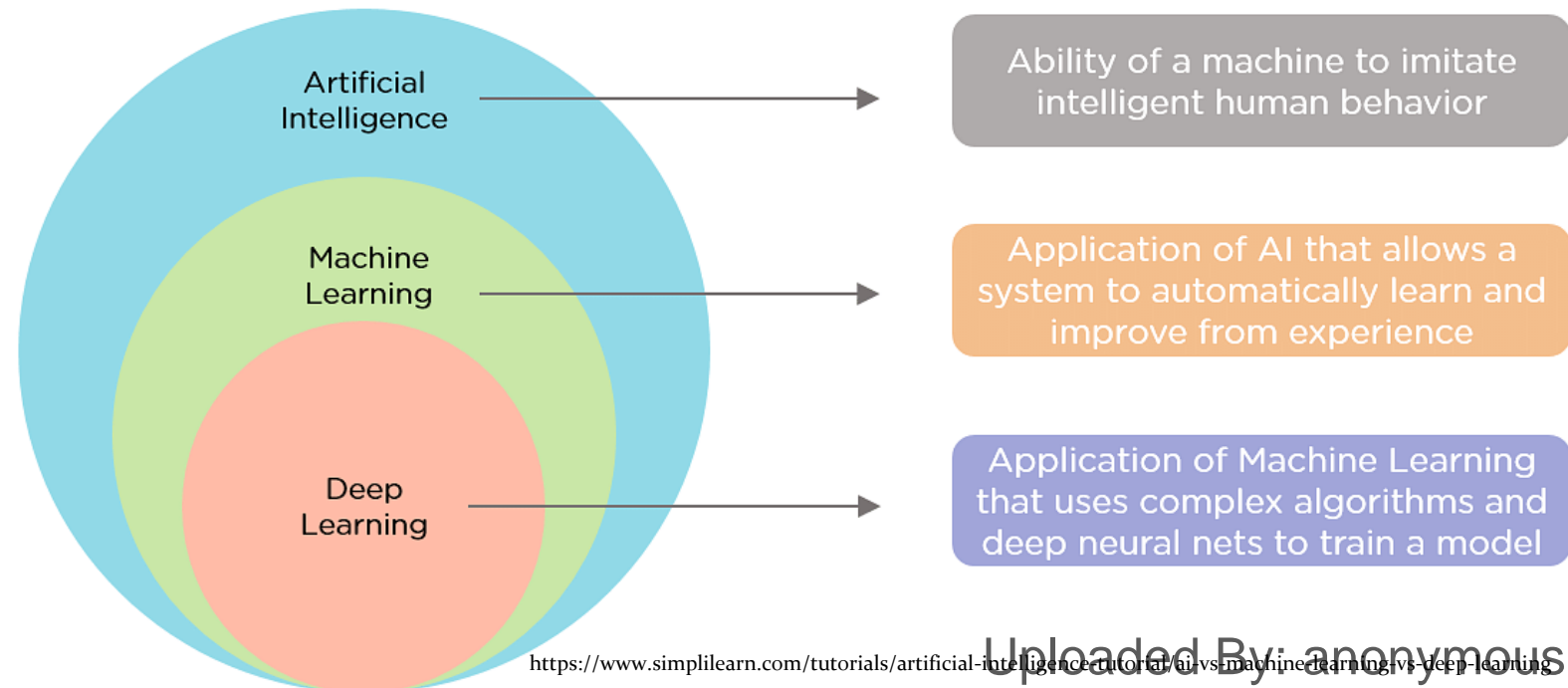
What is Artificial Intelligence?

- "Intelligence: the ability to learn and solve problems" Webster's Dictionary.

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

Artificial Intelligence & Machine Learning

- AI is the broad family of Machine Learning

- AI is the study of how to create intelligent agents

- How to program the computer to behave and perform as a intelligent agent (i.e., a human)

- This may not involve training or learning from data!

Artificial Intelligence → Ability of a machine to imitate intelligent human behavior

Machine Learning → Application of AI that allows a system to automatically learn and improve from experience

Deep Learning → Application of Machine Learning that uses complex algorithms and deep neural nets to train a model

https://www.simplilearn.com/tutorials/artificial-intelligence-tutorial/ai-vs-machine-learning-vs-deep-learning

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What is Artificial Intelligence? 4-schools of thoughts

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

- Artificial Intelligence: A Modern Approach 3rd Ed., page 2

What is Artificial Intelligence?
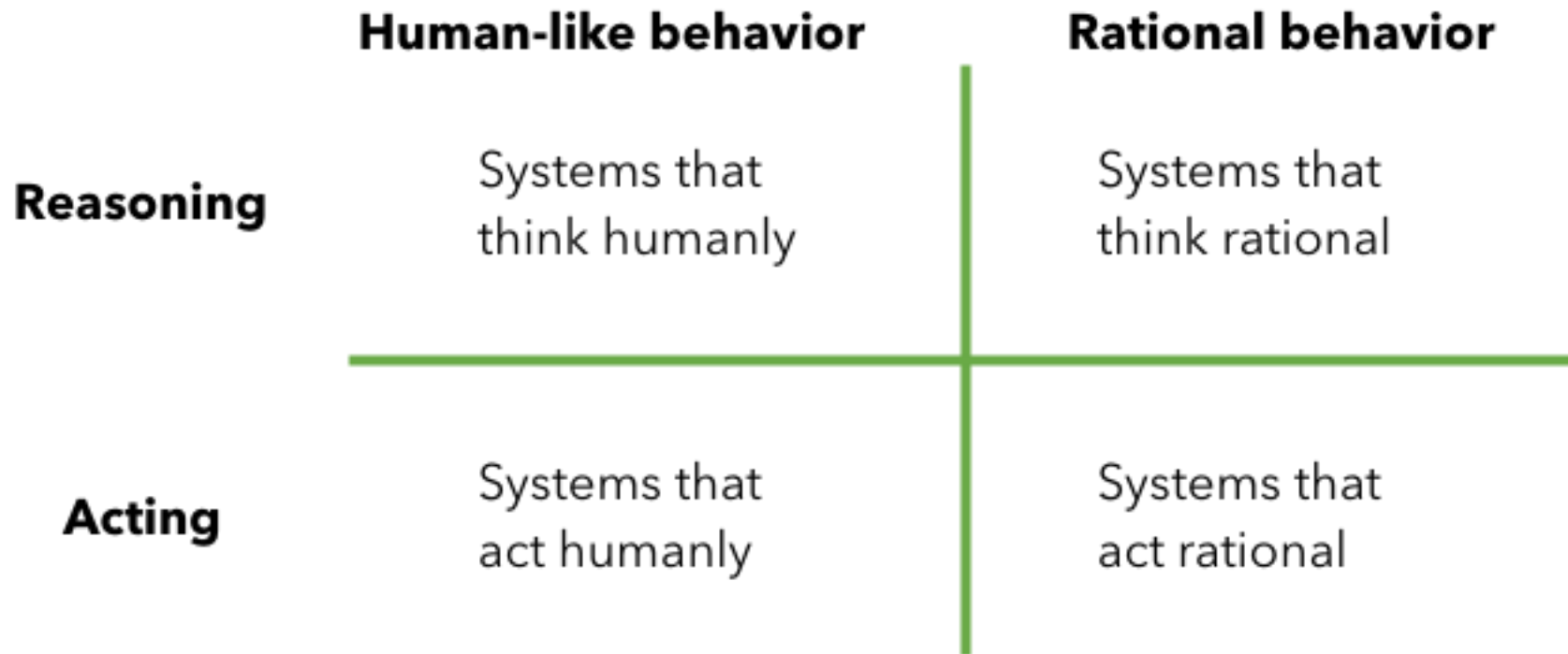
Thought processes & Reasoning

Success in terms of HUMAN performance

Thinking Humanly

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"[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solv-ing, learning . . ." (Bellman, 1978)

Thinking Rationally

"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985)

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Acting Humanly

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Acting Rationally

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Ideal performance measure: RATIONALITY

- A system is rational if it does the "right thing," given what it knows.

Behaviour

What is Artificial Intelligence?

|	**Human-like behavior**	**Rational behavior**
Reasoning	Systems that think humanly	Systems that think rational
Acting	Systems that act humanly	Systems that act rational

Turing Test

- Alan Turing is a British Mathematician and Computer Scientist

- The **Turing Test**, proposed by Alan Turing (1950), was designed to provide a satisfactory operational definition of intelligence

- Instead of asking, 'Can machines think?', Turing said we should ask, 'Can machines pass a behaviour test for intelligence?'

Turing Test
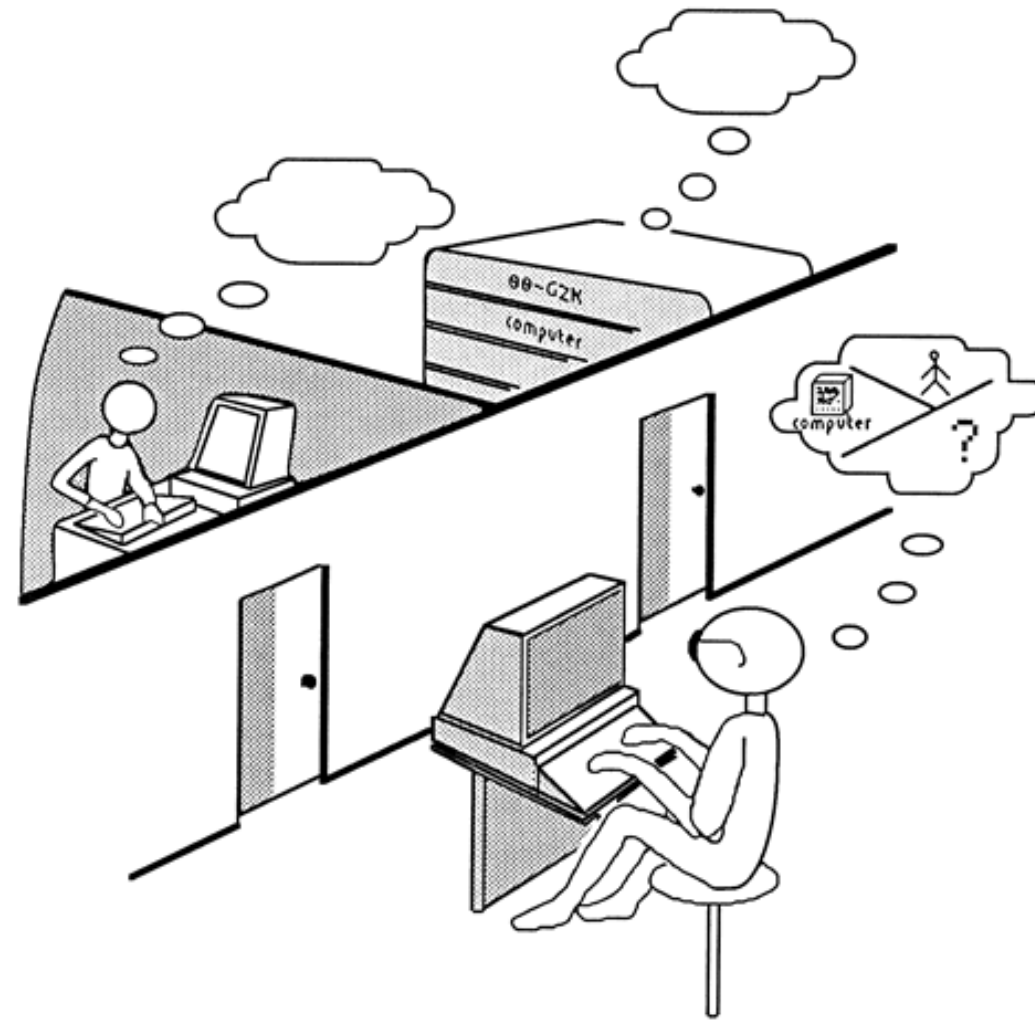
Features of Turing Test

- It attempts to give an objective notion of intelligence, i.e., the behavior of a known intelligent being in response to a particular set of questions.

- This provides a standard for determining intelligence that avoids the inevitable debates over its "true" nature

Turing Test

- A computer passes the test if a human interrogator (or a panel of judges), after posing some written questions, cannot tell whether the written responses come from a person or from a computer

- Tremendous advancements in AI systems; some could pass the Turing test

  - Eugene Goostman: A chatbot that passed the Turing test in 2014. 33% of human judges thought that the system is a human, and the final decision was made it passed the test

  - ChatGPT recently passed the Turing test. It could mimic human-like responses and convince the human evaluators

The six disciplines of AI – the requirements to pass Turing Test

- Natural Language Processing (NLP)
  - To be able to communicate successfully in English
- Knowledge Representation
  - To store what it knows or hears
- Automated Reasoning
  - To use the stored information to answer questions or draw new conclusions
- Machine Learning
  - To Adapt new circumstances and learn new patterns

The six disciplines of AI

- In Total Turing Test (that includes a video signal so that interrogator can test the subject's perceptual ability), the computer needs also:

- Computer Vision

  - To perceive objects

- Robotics

  - To Manipulate objects and move about

Schools of thoughts about Artificial Intelligence

Thinking Humanly

- If we understand how the human brain works, we can simulate it into a computer program.

- Can be achieved in three ways
  - through psychological experiments—observing a person in action
  - through introspection—trying to catch our own thoughts as they go by
  - through brain imaging—observing the brain in action

Thinking Humanly

- Once we have a sufficient precise theory of the mind, it is possible to express the theory as a computer program
- **Cognitive science** brings together computer models from AI and experimental techniques from psychology to construct precise and testable theories of the human mind
- Cognitive scientists, psychologists, and neuroscientists contribute to this field

Thinking Rationally

- Based on logic
- A logic-based AI system that uses set of rules (i.e., syllogisms) to draw conclusions
- Aristotle attempted to codify the "right thinking", that is reasoning processes
- His **syllogisms** provided patterns for argument structures that always yielded correct conclusions when given correct premises
- E.g., "Socrates is a man; all men are mortal; therefore, Socrates is mortal."

Thinking Rationally

- **<u>Logic</u>** is concerned with laws of thought that are supposed to govern the operations of the mind

- In 1965, programs existed that could, in principle, solve *any* solvable problem described in logical notation

- The **logicist** tradition within artificial intelligence hopes to build on such programs to create intelligent systems

Acting Rationally

- **<u>Agents</u>** are expected to operate autonomously, perceive their environment, adapt to changes, create and pursue goals, …
- A rational agent is one that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome
- The skills needed to pass the Turing test allow an agent to act rationally
- Knowledge representation and reasoning enable agents to reach good decisions

Acting Humanly

- This explains if the system can act humanly

History of AI

- 50s/60s—AI can draw logical conclusions, create simple plans, and some initial work on Neural Networks

- Early translation solution from Russian to English but had problem in term **Ambiguity**

  - E.g., "The spirit is willing but the flesh is weak" becomes "The vodka is good but the meat is rotten"

- Another problem rose is the **scalability/complexity** as solutions were small and couldn't scale to large problems

History of AI

- 70s/80s—Expert systems
- Systems that are specialized at solving specific tasks based on experts' knowledge
- Many solutions were widely adapted and funded but faced similar issues as highlighted earlier

History of AI

- Modern AI is more scientific, mathematical, formal, and rigorous

- Divided into many sub-areas interested in particular aspects

- Connected to other disciplines such as Computer Science, Statistics, Operations Research, Economics, Biology, Neuroscience, Psychology, …

Areas of AI

- Planning
- Learning
- Reasoning under uncertainty
- Natural Language Processing
- Knowledge representation—including formal logic
- Search—including heuristic search (puzzles, games, etc.)
- Robotics and Computer Vision Applications

Examples

- **Robot Vehicle**: Google self-driving car
- Speech Recognition: Siri, Google Voice, Cortana!
- **Game Playing**: IBM's DEEP BLUE became the first computer program to defeat the world champion in a chess match when it bested Garry Kasparov
- **Spam Filters**: spam filters in emails (Pattern recognition through learning)

Examples

- **Logistics planning**: During the Gulf war in 1991, the U.S. forces deployed a Dynamic Analysis and Replanning Tool to do automated logistics planning and scheduling for transportation for 50,000 vehicles, cargo, and people at a time, and had to account for starting points, destinations, routes, and conflict resolution among all parameters. Minimised the planning process from weeks to hours

Examples

- **Robotics**: The iRobot Corporation has sold over two million Roomba robotic vacuum cleaners for home use.

- **Machine Translation**: in 2007, a computer program translated Arabic to English from examples of English text totalling two trillion words (Brants *et al.,* 2007). None of the computer scientists on the team speak Arabic, but they do understand statistics and machine learning algorithms