[Unit 1: Introduction]

Artificial Intelligence (MDS 556)

Master in Data Science

Intelligence

Scientists have proposed two major "consensus" definitions of intelligence:

(i) from *Mainstream Science on Intelligence* (1994);

A very general mental capability that, among other things**, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience**. It is not merely book learning, a narrow academic skill, or test-taking smarts. Rather, it reflects a broader and deeper capability for comprehending our surroundings- **making sense" of things, or "figuring out" what to do**.

(ii) from *Intelligence: Knowns and Unknowns* (1995);

Individuals differ from one another in their ability **to understand complex ideas, to adapt effectively to the environment, to learn from experience, to engage in various forms of reasoning, [and] to overcome obstacles by taking thought**. Although these individual differences can be substantial, **they are never entirely consistent: a given person's intellectual performance will vary on different occasions, in different domains, as judged by different criteria**. Concepts of "intelligence" are attempts to clarify and organize this complex set of phenomena.

Thus, ***intelligence*** is:

- the ability to reason
- the ability to understand
- the ability to create
- the ability to Learn from experience
- the ability to plan and execute complex tasks

What is Artificial Intelligence?

"Giving machines ability to perform tasks normally associated with *human* intelligence."

AI is intelligence of machines and branch of computer science that aims to create it. AI consists of design of intelligent agents, which is a program that perceives its environment and takes action that maximizes its chance of success. With Ai it comes issues like deduction, reasoning, problem solving, knowledge representation, planning, learning, natural language processing, perceptron, etc.

"Artificial Intelligence is the part of computer science concerned with designing intelligence computer systems, that is, systems that exhibit the characteristics we associate with intelligence in human behavior."

Different definitions of AI are given by different books/writers. These definitions can be divided into two dimensions.

Systems that think like humans	**Systems that think rationally**
"The exciting new effort to make computers think…..*machine with minds*, in the full and literal sense." (Haugeland, 1985) "[The automaton 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)
Systems that act like humans	**Systems that act rationally**
" The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990) "The study of how to make computer 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)

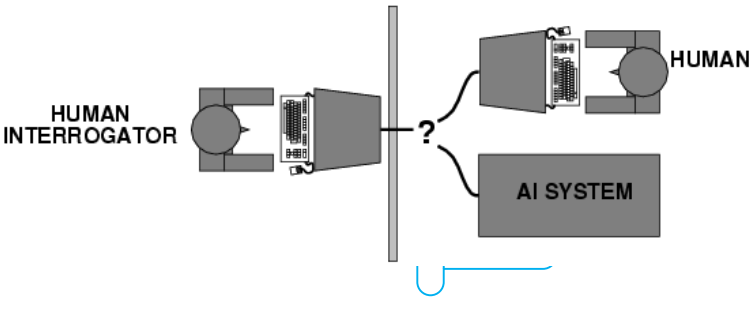
Top dimension is concerned with ***thought processes and reasoning***, where as bottom dimension addresses the ***behavior***.

The definition on the left measures the success in terms of fidelity of *human performance*, whereas definitions on the right measure an *ideal concept of intelligence*, which is called **rationality**.

Human-centered approaches must be an empirical science, involving hypothesis and experimental confirmation. A rationalist approach involves a combination of mathematics and engineering.

Acting Humanly: The Turing Test Approach

The **Turing test**, proposed by Alan Turing (1950) was designed to convince the people that whether a particular machine can think or not. He suggested a test based on indistinguishability from undeniably intelligent entities- human beings. **The test involves an interrogator who interacts with one human and one machine. Within a given time the interrogator has to find out which of the two the human is, and which one the machine**.



The computer passes the test if a human interrogator after posing some written questions, cannot tell whether the written response come from human or not.

To pass a Turing test, a computer must have following capabilities:

- Natural Language Processing: Must be able to communicate successfully
- Knowledge representation: To store what it knows and hears.
- Automated reasoning: Answer the Questions based on the stored information.
- Machine learning: Must be able to adapt in new circumstances.

Turing test avoid the physical interaction with human interrogator. Physical simulation of human beings is not necessary for testing the intelligence.

The total Turing test includes video signals and manipulation capability so that the interrogator can test the subject's perceptual abilities and object manipulation ability. To ass the total Turing test computer must have following additional capabilities:

- Computer Vision: To perceive objects
- Robotics: To manipulate objects and move

Thinking Humanly: Cognitive modeling approach

If we are going to say that a given program thinks like a human, we must have some way of determining how humans think. We need to get inside the actual workings of **human minds**. There are two ways to do this:

- **through introspection:** catch our thoughts while they go by
- **through psychological experiments:** observing a person in action; and through brain imaging—observing the brain in action

Once we have precise theory of mind, it is possible to express the theory as a computer program. If the program's input–output behavior matches corresponding human behavior, that is evidence that some of the program's mechanisms could also be operating in humans.

The field of cognitive science brings together computer models from AI and experimental techniques from psychology to try to construct precise and testable theories of the workings of the human mind.

Think rationally: The laws of thought approach

Aristotal was one of the first who attempt to codify the *right thinking* that is irrefutable reasoning process. He gave Syllogisms that always yielded correct conclusion when correct premises are given.

For example:

Ram is a man
All men are mortal
⇨ Ram is mortal

These law of thought were supposed to govern the operation of mind: This study initiated the field of logic. The logicist tradition in AI hopes to create intelligent systems using logic programming.

However there are two obstacles to this approach. First, it is not easy to take informal knowledge and state in the formal terms required by logical notation, particularly when knowledge is not 100% certain. Second, solving problem principally is different from doing it in practice. Even problems with certain dozens of fact may exhaust the computational resources of any computer unless it has some guidance as which reasoning step to try first.

Acting Rationally: The rational Agent approach:

Agent is something that acts. Of course, all computer programs do something but computer agent is expected to have following attributes:

- Autonomous control
- Perceiving their environment
- Persisting over a prolonged period of time
- Adapting to change
- Create and pursue goals

Rational behavior: doing the right thing.

The right thing: that which is expected to maximize goal achievement, given the available information.

Rational Agent is one that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome.

In the "laws of thought" approach to AI, the emphasis was given to correct inferences. Making correct inferences is sometimes part of being a rational agent, because one way to act rationally is to reason logically to the conclusion and act on that conclusion. On the other hand, there are also some ways of acting rationally that cannot be said to involve inference. *For Example, recoiling from a hot stove is a reflex action that usually more successful than a slower action taken after careful deliberation.*

This approach has following advantages over other;

- It is more general than laws of thought approach, because correct inference is just one of several mechanisms for achieving rationality.

- It is more amenable to scientific development than are approaches based on human behavior or human thought because the standard of rationality is clearly defined and completely general.

Characteristics of AI Programs

- **Symbolic Reasoning:** reasoning about objects represented by symbols, and their properties and relationships, not just numerical calculations.
- **Knowledge:** General principles are stored in the program and used for reasoning about novel situations.
- **Search:** a `weak method" for finding a solution to a problem when no direct method exists.
- **Flexible Control:** Direction of processing can be changed by changing facts in the environment.

Foundations of AI:

***Philosophy*:**
Logic, reasoning, mind as a physical system, foundations of learning, language and rationality.

- Where does knowledge come from?
- How does knowledge lead to action?
- How does mental mind arise from physical brain?
- Can formal rules be used to draw valid conclusions?

***Mathematics*:**
Formal representation and proof algorithms, computation, undecidability, intractability, probability.

- What are the formal rules to draw the valid conclusions?
- What can be computed?
- How do we reason with uncertain information?

***Psychology*:**
Adaptation, phenomena of perception and motor control.

- How humans and animals think and act?

***Economics*:**
Formal theory of rational decisions, game theory, operation research.

- How should we make decisions so as to maximize payoff?
- How should we do this when others may not go along?
- How should we do this when the payoff may be far in future?

***Linguistics*:**
Knowledge representation, grammar

- How does language relate to thought?

***Neuroscience*:**
Physical substrate for mental activities

- How do brains process information?

Computer Engineering:

- How do we build efficient computers?

***Control Theory*:**
Homeostatic systems (devices containing appropriate feedbacks to achieve stable adaptive behaviour), stability, optimal agent design

- How can artifacts operate under their own control?

History of AI

The gestation of of AI (1943-1955):

- 1943: Warren Mc Culloch and Walter Pitts: a model of artificial boolean neurons to perform computations.
  - First steps toward connectionist computation and learning (Hebbian learning).
  - Marvin Minsky and Dann Edmonds (1951) constructed the first neural network computer

- 1950: Alan Turing's "Computing Machinery and Intelligence"
  - First complete vision of AI.

The birth of AI (1956):
- Dartmouth Workshop bringing together top minds on automata theory, neural nets and the study of intelligence.
  - Allen Newell and Herbert Simon: The logic theorist (first nonnumeric thinking program used for theorem proving)

- For the next 20 years the field was dominated by these participants.

Great expectations (1952-1969):

- Newell and Simon introduced the General Problem Solver.
  - Imitation of human problem-solving
- Arthur Samuel (1952-) investigated game playing (checkers) with great success.
- John McCarthy(1958-) :
  - Inventor of Lisp (second-oldest high-level language)
  - Logic oriented, Advice Taker (separation between knowledge and reasoning)

- Marvin Minsky (1958 -)
  - Introduction of microworlds that appear to require intelligence to solve: e.g. blocks-world.
  - Anti-logic orientation, society of the mind.

A dose of reality (1966 - 1973):

- Progress was slower than expected.
  - Unrealistic predictions.
  - programs knew nothing of their subject matter; they succeeded by means of simple syntactic manipulations
- Some systems lacked scalability.
  - Combinatorial explosion in search.
  - Most of the early AI programs solved problems by trying out different combinations of steps until the solution was found. This strategy worked initially because microworlds contained very few objects and hence very few possible actions and very short solution sequences.
  -

AI revival through knowledge-based systems (1969-1979):

- General-purpose vs. domain specific
  - E.g. the DENDRAL project (Buchanan et al. 1969)
    First successful knowledge intensive system. The problem of inferring molecular structure from the information provided by a mass spectrometer.

- Expert systems
  - MYCIN to diagnose blood infections (Feigenbaum et al.)
    Included introduction of uncertainty in reasoning.

- Increase in knowledge representation research.
  - Logic, frames, semantic nets, …

AI becomes an industry (1980 - present):

- R1: Commercial Expert system
- Fifth generation project in Japan (1981) to build intelligent computers running prolog.
- American response …

Puts an end to the AI winter, where many companies failed to deliver on extravagant promises.

Connectionist revival (1986 - present): (Return of Neural Network):

- Parallel distributed processing (RumelHart and McClelland, 1986);
- Connectionist approach and backpropagation.

AI becomes a science (1987 - present):

- In speech recognition: hidden markov models
- In neural networks
- In uncertain reasoning and expert systems: Bayesian network formalism
- Data Mining

The emergence of intelligent agents (1995 - present):

- The whole agent problem:

  "How does an agent act/behave embedded in real environments with continuous sensory inputs:

  AI systems have become so common in Web-based applications that the "-bot" suffix has entered everyday language

- Human Level AI: machines that think, learn and create. Eg: Driving Cars, recognizing speech etc.
- Artificial General Intelligence: universal algorithm for learning and acting in any environments

Availability of Very Large Datasets (2001 - present):

- Throughout the 60-year history of computer science, the emphasis has been on the *algorithm* as the main subject of study. But some recent work in AI suggests that for many problems, it makes more sense to worry about the *data* and be less picky about what algorithm to apply.
- **Suppose you use Photoshop to mask out an ex-(girl/boy) friend from a group photo, but now you need to fill in the masked area with something that matches the background.**
- Use an algorithm that searches through a collection of photos to find something that will match. The algorithm may work poor when used with a collection of only ten thousand photos, but may cross a threshold into excellent performance when grew the collection to two million photos
- "AI Winter" may be yielding to a "New Spring"

Applications of AI:

Few sample applications of AI include:

Robotic vehicles: A driverless robotic car named STANLEY sped through the rough terrain of the Mojave dessert at 22 mph, finishing the 132-mile course first to win the 2005 DARPA Grand Challenge. STANLEY is a Volkswagen Touareg outfitted with cameras, radar, and laser rangefinders to sense the environment and onboard software to command the steering, braking, and acceleration

Speech recognition: A traveler calling United Airlines to book a flight can have the entire conversation guided by an automated speech recognition and dialog management system.

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

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 by a score of 3.5 to 2.5 in an exhibition match.

Spam fighting: Each day, learning algorithms classify over a billion messages as spam, saving the recipient from having to waste time deleting what, for many users, could comprise 80% or 90% of all messages, if not classified away by algorithms.

Logistics planning: During the Persian Gulf crisis of 1991, U.S. forces deployed a Dynamic Analysis and Replanning Tool, DART (Cross and Walker, 1994), to do automated logistics planning and scheduling for transportation.

Robotics: The iRobot Corporation has sold over two million Roomba robotic vacuum cleaners for home use. The company also deploys the more rugged PackBot to Iraq and Afghanistan, where it is used to handle hazardous materials, clear explosives, and identify the location of snipers.

Machine Translation: A computer program automatically translates from one language to other.

Explore Recent:

- **TikTok Algorithm**
- **https://ai.facebook.com/**
- **PUBG finish placement prediction**
- **AI in Zoom** (Zoom introduced virtual backgrounds for mobile, laptop, and desktop devices. They have introduced advanced AI background noise detection to automatically reduce environmental noises, such as fans, dogs barking, and vacuum cleaners.)
- And many more ….