Artificial Intelligence: An introduction

When something is said to be *artificial*, it means it is contrived by art rather than nature. It also connotes something that neither arises from natural growth nor is characterised by vital processes.
There are several definitions for *intelligence*. Intelligence is:

- The faculty of understanding
- The capacity to know or apprehend
- The ability as measured by tests or social criteria
- The ability to use knowledge in new situations or problems
- The ability to learn
- The ability to plan and foresee problems
- The ability to use symbols and relationships
- The ability to think abstractly and to work towards a goal
- The ability to perform some of the functions of a computer

Artificial Intelligence may be defined as the branch of computer science that is concerned with the automation of intelligent behaviour. This definition is particularly useful in this course as we are seeking to define AI as part of computer science.

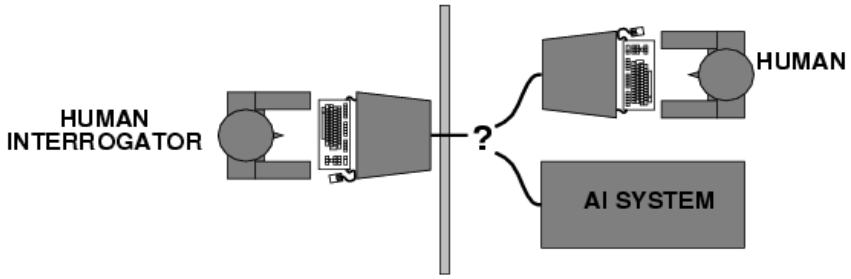
Because of its scope, AI generally defies a simple definition as it has always been more concerned with expanding the capabilities of computer science, rather than defining its limits.
Due to this simple fact, there are several other definitions of AI. Some of these are enumerated below:

- Getting computers to do things which would be considered intelligent if done by people
- The study of mental faculties through the use of computational models
- Computer modelling of human mental abilities
- Technology of getting computers to do things that seem intelligent
- Creating computers that ‘think’
- Collection of problems and methodologies studied by AI researchers
- Study of how to make real computes act like ones in movies
- Exploration of the design spaces of intelligences

Now, AI is both the process of attempting to understand intelligence by attempting to model it computationally (scientists’ explanation), and also the process of attempting to utilise intelligence by attempting to model it computationally (engineers’ explanation).

There are four categories of approaching AI:

- **Systems that act humanly**
  - This is well represented by the Turing test approach. This is to test whether a system can behave intelligently enough to fool a human interrogator.



    It was basically to measure the performance of an allegedly intelligent machine against that of a human being, arguably the best and only standard for intelligent behaviour. Important features of Turing's test are:
    - It attempts to give an objective notion of intelligence, i.e., the behaviour of a known intelligent being in response to a particular set of questions
    - It prevents us from being sidetracked by such confusing and currently unanswerable question as to whether or not the computer uses the appropriate internal processes or whether or not the machine is actually conscious of its actions.
    - It eliminates any bias in favour of living organisms by forcing the interrogator to focus solely on the content of the answers to questions.
- **Systems that think humanly**
  - This is a cognitive modelling approach, which is now distinct from AI. This requires scientific theories of internal activities of the brain. Example, To what level of abstraction are we looking at? What is knowledge?
  - Validating this requires a predicting and testing of behaviours of human subjects. This will involve direct identification from neurological data.
- **Systems that think rationally**
  - This involves the laws of thought approach. It is a direct line through mathematics and philosophy to modern AI. It is normative (or prescriptive) rather than descriptive.
  - Problems that arise from systems thinking rationally are:
    - Not all intelligent behaviour is mediated by logical deliberation
    - What is the purpose of thinking?
    - What thought should one have out of all the thoughts (logical or otherwise) that one could have?

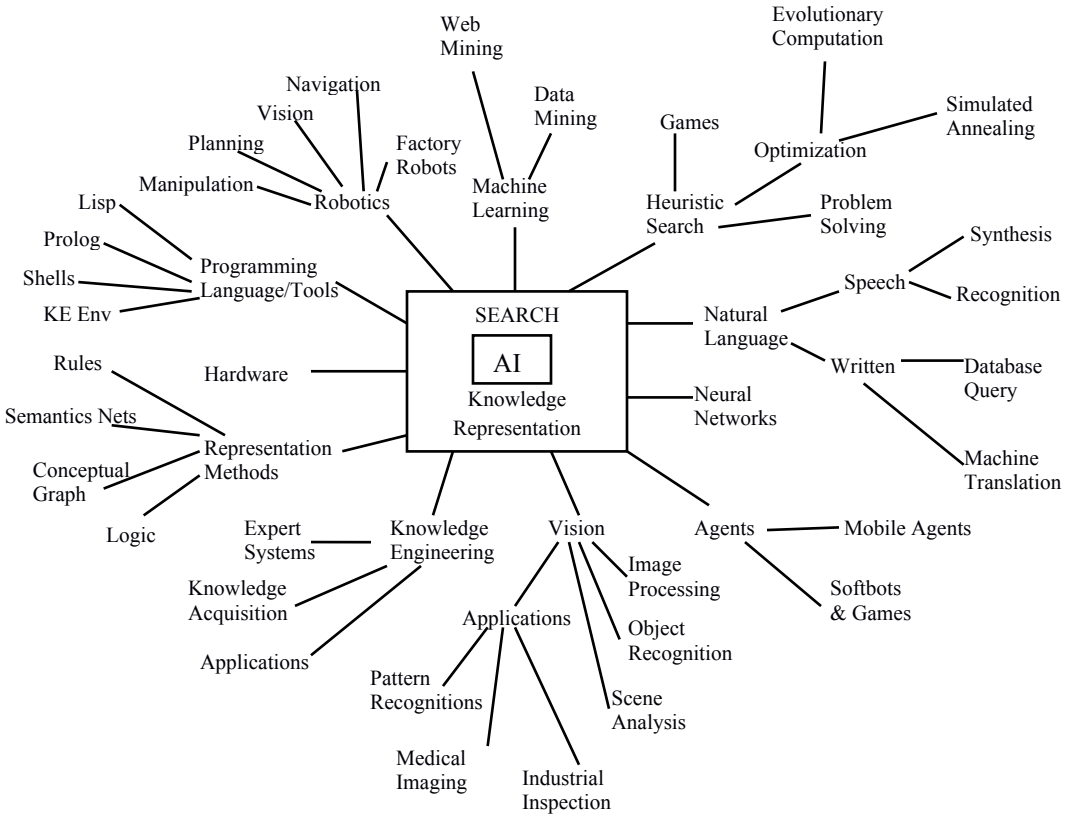
- **Systems that act rationally**
    - This is the rational agent approach which involves doing the right thing. Here, the "right thing" is that which is expected to maximise goal achievement, given the available information. Rational behaviour does not necessarily involve thinking. E.g., blinking is a rational behaviour but it is reflex. Thinking however should be in the service of rational action.

Foundations of AI

There are several foundations of AI. Some of these include

- Philosophy – the rational investigation of questions about existence and knowledge and ethics.
    - Logic
    - Methods of reasoning
    - The mind as a physical system
    - Foundations of learning
    - Language
    - Rationality
- Mathematics – a science that deals with the logic of quantity and shape and arrangement.
    - Formal representation and proof
    - Algorithms
    - Computations
    - Decidability
    - Tractability
    - Probability
- Psychology – the science of mental life.
    - Adaptation
    - Perception
    - Motor control
    - Experimental
- Economics – a branch of social science that deals with the production and distribution and consumption of goods and services and their management.
    - Formal theory of rational decisions
- Linguistics – the scientific study of language.
    - Knowledge representation
    - Grammar
- Neuroscience – the scientific study of the nervous system.
    - Plastic physical substrate for mental activity

Sample Map of AI



Possible Applications

- Robotics
- Machine learning
- Agents
- Programming languages / tools
- Heuristic search
- Natural language
- Neural networks
- Vision
- Knowledge engineering
- Representation methods
- Hardware

Intelligence

There are many definitions of intelligence. A person that learns fast or one that has a vast amount of experience could be called "intelligent". However for our purposes the most useful definition is: ***a system's comparative level of performance in reaching its objectives***. This implies having experiences where the system learned which actions best let it reach its objectives. The core definition for intelligence is the ability to comprehend, understand and profit from experience.

System

A system is part of the universe, with a limited extension in space and time. What is outside the frontier of the system, we call its environment. Stronger or more correlations exist between one part of the system and another, than between this part of the system and parts in the environment. A system can also be defined as any of the following:

- A group of independent but interrelated elements comprising a unified whole
- A set of interacting or interdependent entities forming an integrated whole.
- A set of rules that governs behaviour or structure

The concept of an ***'integrated whole'*** can also be stated in terms of a system embodying a set of relationships. These can be an intra-relationship (between members of the embodied set) or an inter-relationship (between the embodied set and another system as a whole or of its individual systems).

The general study of systems includes an investigation into abstract properties of the systems' organisation, searching concepts and principles, substance, type and categories of existence.

Most systems share common characteristics like

- Structure – defined by parts and their composition
- Behaviour – involves inputs, processing and outputs (of information, energy, etc)
- Interconnectivity – various parts have functional and structural(between parts) relationships

- Functions – by itself or in groups

Intelligent Systems

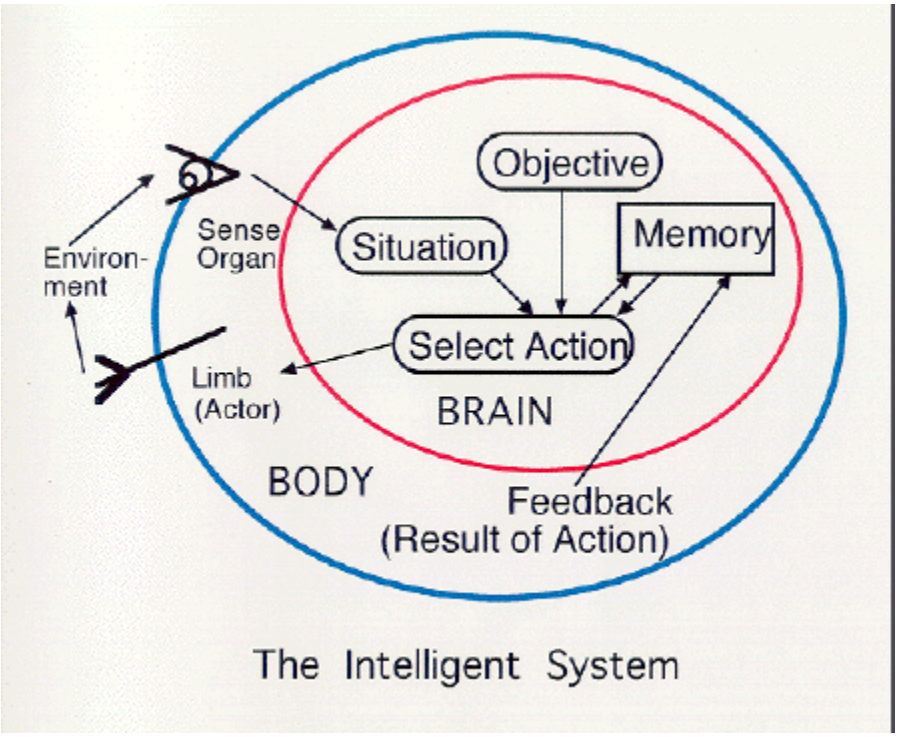
An intelligent system is therefore a combination of the following:

- A system
- It learns during its existence (it senses its environment and learns, for each situation, which action permits it to reach its objectives.). Learning is the increase in the amount of response rules and concepts in the memory of an intelligent system.
- It continually acts, mentally and externally, and by acting, reaches its objectives more often than pure chance indicates.
- It consumes energy and uses that energy for its internal processes in order to act.

What does this definition imply?

- The system has to exist.
- An environment must exist, with which the system can interact.
- It must be able to receive communications from the environment, for its elaboration of the present situation. This is an abstracted summary of the communications received by the senses. By communications, in turn, we mean an interchange of matter or energy. If this communication is for the purpose of transmitting information, it is a variation of the flow of energy or a specific structuring of matter that the system perceives.
- The IS has to have an objective, it has to be able to check if its last action was favourable, if it resulted in getting nearer to its objective, or not.
- To reach its objective it has to select its response. A simple way to select a response is to select one that was favourable in a similar previous situation.
- It must be able to learn. Since the same response sometimes is favourable and sometimes fails, it has to be able to recall in which situation the response was favourable, and in which it was not. Therefore it stores situations, responses, and results.
- Finally, it must be able to act; to accomplish the selected response.

Structure of the Functioning of an IS



The IS is fundamentally a type of ***stimulus-response system***. The stimulus is the sum of the communications entering through the senses. The 'brain' extracts information from this and represents it as a situation. Next, the IS selects a response rule that is appropriate to the situation and performs the response part of this rule. Here what we mean by "appropriate" is that performing the response permits the system to get nearer to the situation that is its objective.

The IS makes its selection of response rules from those that it finds stored in its memory. In this memory, the IS has accumulated response rules that it has generated from earlier experiences and from generalizations based on previously elaborated response rules.

What makes a system intelligent?

For a system to be noted as intelligent, it must be able to:

- Think like humans
- Act like humans

- Think rationally
- Act rationally

Systems' thinking is the process of predicting, on the basis of anything at all, how something influences another thing. It is an approach to problem solving by viewing problems as parts of an overall system, rather than reacting to present outcomes or events and potentially contributing to further development of the undesired issue or problem.

Essential Abilities for Intelligence

- To respond to situations flexibly
- To take advantage of fortuitous circumstances
- To make sense out of ambiguous or contradictory messages
- To recognize the relative importance of different elements of a situation
- To find similarities between situations despite differences that may separate them
- To draw distinctions between situations despite similarities that may relate them
- To synthesize new concepts by taking old concepts and putting them together in new ways
- To come up with novel ideas

Some intelligent systems

- GPS navigation
- MapQuest, Google, Wikipedia
- Voice response systems
- Chess, checkers, computer games

Cognitive and biological paradigms

Cognition – the psychological result of perception and learning and reasoning
Biological – pertaining to biology or to life and living things

Thinking involves the following:

- Syntax (form) and semantics (meaning)
- Algorithmic vs non-algorithmic behaviour
- Consistency, emotion, “The collective subconscious”
- Generating alternatives
- Randomised search

Consciousness comprises the following:

- Self-awareness and perception
- Creativity , wisdom and imagination
- Common sense, understanding and judgement of truth
- Learning by example

Philosophical questions about machine-intelligent control

- Must intelligent machines be ***better than humans*** in order to be adopted?
- Which decisions can the machine make without ***human supervision***?
- How much information should the machine ***display to the human operator***?
- May machine-intelligent systems make ***mistakes*** (at the same level as humans)?
- May intelligent systems ***gamble*** when uncertain (as humans do)?
- Can (or Should) intelligent systems exhibit "***personality***”?
    - *"the complex of characteristics that distinguishes an individual, the totality of behavioral and emotional tendencies, the organization of distinguishing traits...", Webster's New Collegiate Dictionary (extroversion, conscientiousness, agreeableness, openness, neuroticism)*
- Can (or Should) intelligent systems express "***emotion***”?
    - *"a psychic and physical reaction experienced physiologically involving changes that prepare the body for immediate vigorous action...", ibid (love, hate, friendship, anger, fear)?*
- Is ***on-line learning*** necessary or desirable for machine intelligence?

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