Study Unit 1: Introduction to AI

Introduction

- Artificial Intelligence (AI) is a branch of science which deals with helping machines find solutions to complex problems in a more human-like fashion.
- This generally involves borrowing characteristics from human intelligence, and applying them as algorithms in a computer friendly way.
- A more or less flexible or efficient approach can be taken depending on the requirements established, which influences how artificial the intelligent behavior appears
- Artificial intelligence can be viewed from a variety of perspectives.
    - From the perspective of intelligence artificial intelligence is making machines "intelligent" -- acting as we would expect people to act.
        - The inability to distinguish computer responses from human responses is called the Turing test.
        - Intelligence requires knowledge
        - Expert problem solving - restricting domain to allow including significant relevant knowledge
    - From a business perspective AI is a set of very powerful tools, and methodologies for using those tools to solve business problems.
    - From a programming perspective, AI includes the study of symbolic programming, problem solving, and search.
    - Typically AI programs focus on symbols rather than numeric processing.
    - Problem solving - achieve goals.
    - Search - seldom access a solution directly. Search may include a variety of techniques.
    - AI programming languages include:
        - *LISP, developed in the 1950s, is the early programming language strongly associated with AI. LISP is a functional programming language with procedural extensions. LISP (LISt Processor) was specifically designed for processing heterogeneous lists -- typically a list of symbols.*

Features of LISP are run- time type checking, higher order functions (functions that have other functions as parameters), automatic memory management (garbage collection) and an interactive environment.

- *The second language strongly associated with AI is PROLOG. PROLOG was developed in the 1970s. PROLOG is based on first order logic. PROLOG is declarative in nature and has facilities for explicitly limiting the search space.*
- *Object-oriented languages are a class of languages more recently used for AI programming. Important features of object-oriented languages include: concepts of objects and messages, objects bundle data and methods for manipulating the data, sender specifies what is to be done receiver decides how to do it, inheritance (object hierarchy where objects inherit the attributes of the more general class of objects). Examples of object-oriented languages are Smalltalk, Objective C, C++. Object oriented extensions to LISP (CLOS - Common LISP Object System) and PROLOG (L&O - Logic & Objects) are also used.*

- Artificial Intelligence is a new electronic machine that stores large amount of information and process it at very high speed
- The computer is interrogated by a human via a teletype It passes if the human cannot tell if there is a computer or human at the other end
- The ability to solve problems
- It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence

Definitions

i. **AI (Ability):** The ability of a machine (device) to perform functions that are normally associated with human intelligence, such as reasoning, planning, recognition, perception, cognition, learning, understanding, and problem-solving.

ii. **AI (Discipline):** A branch of the computer science that deals with the research, design and application of the intelligent computer. Its major objective is to develop and use a machine to imitate some intellectual capabilities of human brain and to develop the related theories and techniques.

iii. **Artificial intelligence:** It is the science and engineering of making intelligent machines, especially intelligent computer programs. (John McCarthy)

iv. **Intelligence** is the computational part of the ability to achieve goals in the world. Varying kinds and degrees of intelligence occur in people, many animals and some machines.

Box 1.1: Definition of AI

Artificial Intelligence (AI) is a branch of science which deals with helping machines find solutions to complex problems in a more human-like fashion.

Intelligent Machine: A kind of machine that can perform various anthropomorphic tasks in an environment by learning autonomously or interactively.

Intelligent System: A system that can drive or operate intelligent machine to reach its goal.

Intelligent Science: A discipline that studies the essences of the human-being intelligent behavior, simulates the intelligence of human and living beings, and realizes various intelligent systems.

What's involved in Intelligence?

- **Ability to interact with the real world**
    - to perceive, understand, and act
    - e.g., speech recognition and understanding and synthesis
    - e.g., image understanding
    - e.g., ability to take actions, have an effect
- **Reasoning and Planning**
    - modeling the external world, given input
    - solving new problems, planning, and making decisions
    - ability to deal with unexpected problems, uncertainties
- **Learning and Adaptation**
    - we are continuously learning and adapting
    - our internal models are always being "updated"
        - e.g., a baby learning to categorize and recognize animals

Signs of Intelligence

- Learn or understand from experience
- Make sense out of ambiguous or contradictory messages
- Respond quickly and successfully to new situations
- Use reasoning to solve problems
- Deal with perplexing situations
- Understand and infer in ordinary, rational ways
- Apply knowledge to manipulate the environment
- Think and reason
- Recognize the relative importance of different elements in a situation

Turing Test for Intelligence

- The Turing Test, proposed by Alan Turing (1950), was designed to provide a satisfactory operational definition of intelligence. A computer passes the test if a human interrogator, after posing some written questions, cannot tell whether the written responses come from a person or from a computer. A machine that passes the test should certainly be considered intelligent.
- **It states that,** "*A computer can be considered to be smart only when a human interviewer, conversing with both an unseen human being and an unseen computer, cannot determine which is which*".

Can we build hardware as complex as the brain?

- **How complicated is our brain?**
  - a neuron, or nerve cell, is the basic information processing unit
  - estimated to be on the order of 10^{12} neurons in a human brain
  - many more synapses (10^{14}) connecting these neurons
  - cycle time: 10^{-3} seconds (1 millisecond)
- **How complex can we make computers?**
  - 10^8 or more transistors per CPU
  - supercomputer: hundreds of CPUs, 10^{12} bits of RAM

- cycle times: order of 10^{-9} seconds

- **Conclusion**
  - YES: in the near future we can have computers with as many basic processing elements as our brain, but with
    - far fewer interconnections (wires or synapses) than the brain
    - much faster updates than the brain
  - but building hardware is very different from making a computer behave like a brain!

Research & Application Fields of AI

1. Game Playing

- Much of the early research in state space search was done using common board games such as checkers, chess, and the 15-puzzle. In addition to their inherent intellectual appeal, board games have certain properties that made them ideal subjects for research.
- Most games are played using a well-defined set of rules: this makes it easy to generate the search space and frees the researcher from many of the ambiguities and complexities inherent in less structured problems.

2. Automated Reasoning and Theorem Proving

- Theorem-proving research was responsible for much of the early work in formalizing search algorithms and developing formal representation languages such as the predicate calculus and the logic programming language Prolog.
- Most of the appeal of automated theorem proving lies in the rigor and generality of logic. Because it is a formal system, logic lends itself to automation. A wide variety of problems can be attacked by representing the problem description and relevant background information as logical axioms and treating problem instances as theorems to be proved.

3. Expert Systems

- Expert knowledge is a combination of a theoretical understanding of the problem and a collection of heuristic problem-solving rules that experience has shown to be effective in the domain.
- Expert systems are constructed by obtaining this knowledge from a human expert and coding it into a form that a computer may apply to similar problems.
- One major insight gained from early work in problem solving was the importance of domain-specific knowledge. A doctor, for example, is not effective at diagnosing illness solely because she possesses some innate general problem-solving skill; she is effective because she knows a lot about medicine.

4. Natural Language Understanding

- One of the long-standing goals of artificial intelligence is the creation of programs that are capable of understanding and generating human language.
- Understanding natural language involves much more than parsing sentences into their individual parts of speech and looking those words up in a dictionary.
- Real understanding depends on extensive background knowledge about the domain of discourse and the idioms used in that domain as well as an ability to apply general contextual knowledge to resolve the omissions and ambiguities that are a normal part of human speech.
- Consider, for example, the difficulties in carrying on a conversation about baseball with an individual who understands English but knows nothing about the rules, players, or history of the game.

5. Planning and Robotics

- Research in planning began as an effort to design robots that could perform their tasks with some degree of flexibility and responsiveness to the outside world.
- Briefly, planning assumes a robot that is capable of performing certain atomic actions. It attempts to find a sequence of those actions that will accomplish some higher-level task, such as moving across an obstacle-filled room.

6. Machine Learning

- An expert system may perform extensive and costly computations to solve a problem. Unlike a human being, however, if it is given the same or a similar problem a second time, it usually does not remember the solution.
- It performs the same sequence of computations again. This is true the second, third, fourth, and every time it solves that problem hardly the behavior of an intelligent problem solver.
- The obvious solution to this problem is for programs to learn on their own, either from experience, analogy, examples, being "told" what to do, or rewarded or punished depending on results.

  Extracting information from an environment (or a particular domain) is a learning process that after verification, one constructs or builds a knowledge base. There's constant execution and giving a feedback to bring machine learning to perfection is an iterative process model.

7. Automatic Programming

For mobile robots/vehicles working in space, underwater or on land, they have to sense and adapt their environment, to execute the assigned tasks and to design the most suitable program automatically.

Automatic programming is related to automatic theorem proving and robotics, it has the following research area:

- **Program synthesis:** According to the initial description of a given problem, then produce automatically a program to satisfy the requirement of the task and
- **Program verify:** It uses the "old" program to verify the "new" program.

8. Pattern Recognition:

- Pattern Recognition is to recognize the imitate sample of a given object. The "pattern" can be an object, a graph, a voice, a character and/or light signal.

9. Computer Vision

- Research topics of Computer Vision: real-time parallel processing, active and qualitative vision, dynamic and time-varying vision, modeling & recognition of 3-dimension scenes, compression, transmission and retrieval of real-time images, processing and explanation of multi-spectrum and color image.

QUIZ 1.1

1.1 Can machines think? And if so, how? And if not, why not?