UNIT 1 ARTIFICIAL INTELLIGENCE (AI): KEY NOTIONS

Contents

1.0 OBJECTIVES

The objective of this unit is to introduce the key notion of artificial intelligence. . In the first section, we will focus on the various definitions of artificial intelligence, and organize it into the four categories which are, systems that think like humans, systems that act like humans, systems that think rationally and systems that act rationally. In the second and third sections, we will explore the field of AI, and the issue of what computers can do, respectively.

1.1 INTRODUCTION

The object of research in artificial intelligence (AI) is to discover how to program a computer to perform the remarkable functions that make up human intelligence. This work leads not only to increasing use of computers, but also to an enhanced understanding of human cognitive processes which constitute what we mean by 'intelligence', and the mechanisms that are required to produce it. What is needed is a deeper understanding of human intelligence and the human mind. The basic tenet of this thesis is that the brain is just a digital computer and that the mind is a software program. In the last section, we will focus on the relation between AI and the functional theory of mind.

1.2 WHAT IS ARTIFICIAL INTELLIGENCE?

It is difficult to give a precise definition of artificial intelligence. Some recent artificial intelligence scientists have attempted to define artificial intelligence (in short AI) in various ways. According to Haugeland, artificial intelligence is, "the exciting new effort to make computers think … machines with minds, in the full and literal sense (1985)" For Bellman, it is "the automation of activities that we associates with human thinking, activities such as decision making, problem solving, learning…(1978)." Charniak and McDermett define AI as "the study of mental faculties through the use of computational model(1985)." And for Winston, it is "the study of the computations that make it possible to perceive, reason and act (1984)" AI, for Kurzweil is "the art of creating machines that perform functions that require intelligence when performed by people (1990)."

Rich and Knight say that AI is "The study of how to make computers thinks at which, at the movement, people are better (1984)" For Schalkoff, AI is "a field of study that seeks to explain and emulate intelligent behavior in terms of computational process (1990)" Luger and Stubblefield hold it to be "the branch of computer science that is concerned with the automation of intelligent behavior (1993)"

Let us look at all the definitions from different angles. Haugeland and Bellman point out that artificial intelligence is concerned with thought process and reasoning. They have explained the mind as a machine that is completely associated with human thinking. That is to say, computers do think. But Schalkoff, Luger and Stubblefield are concerned with the behavioural aspects of systems. For them, computers behave as intelligently as human beings. Moreover, Kurzweil, Rich and Knight are concerned with or measure success in terms of human performance. For them, artificial intelligence can be attributed to machines, but it belongs basically to the human mind. At last, Charniak, McDermett and Winston are concerned with an ideal intelligence. They explain the mental faculties through the use of computational models.

To sum up, all the definitions of AI can be organized into four categories. They are as follows:

i) Systems that think like humans.

ii) Systems that act like humans.

iii) Systems that think rationally.

iv) Systems that act rationally.

Now, we have to look at each aspect in detail.

i) Acting Humanly: Turing Machine Approach

The Turing test, as named after Alan Turing, was designed to provide a satisfactory operational definition of intelligence. Turing defined that intelligent behavior as the ability to achieve human-level performance in all cognitive tasks to fool an interrogator.[10] In his 'C*omputing Machinery and Intelligence*', Turing says the new form of the problem can be described in terms of a game which we call the '*imitation game*.' It is played by a man (A), a woman (B), and an interrogator (C) who may be of either sex. The interrogator stays in a room apart from the other two. The object of the game for the interrogator is to determine which of the other two is the man and which is the woman. He or She knows them by labels X and Y, and at the end of the game, he or she says, either 'X is A and Y is B' or 'X is B and Y is A.' The interrogator is allowed to put questions to A and B. Thus, C: will X please tell me the length of his or her hair?

Now suppose X is actually A, then A must answer to the question. It is A's object in the game to try to cause C to make the wrong identification. His or her answer might therefore, be 'my hair is singled, and the longest strands are about nine inches long.'

However, because the tones of voice may not help the interrogator, the answer should be written or better still be typewritten. The ideal arrangement is to have a tele-printer for perfect communication. Alternatively, an intermediary can repeat the questions and answers. The object of the game for the second player (B) is to help the interrogator. The best strategy for her is probably to give truthful answers. She can add to her answer such things as ‘I am the woman, do not listen to him,’ but it is of no avail as the man can make similar remark.

Now, we can ask the question, what will happen when a machine takes the part of A in this game? Will the interrogator decide wrongly as often when the game is played like this as he does when the game is played between man and a woman?

Turing’s answers to these questions are more or less summed up in the following passage; “I believe that in about fifty years time it will be possible to program computers, with a storage capacity of about 10^9, to make them play the imitation game so well that an average interrogator will not have more than 70 percent chance of making the right identification after five minutes of questioning (1950)”

What Turing had predicted at that time, now is a fact that the machine or the computer can imitate human behaviuor. It should be pointed out that Turing’s beliefs about the capabilities and capacities of machines are not limited to such activities as playing the imitation game as successfully as human beings. Roughly speaking, the test Turing proposed is that the computer should be interrogated in the place of human beings.

Turing’s test deliberately avoided direct physical interaction between the interrogator and the computer, because physical limitation of a person is unnecessary for intelligence. However, the so-called Turing test includes a-video signal so that the interrogator can test the subject’s perceptual abilities. In order to pass through total Turing test, the computer will need computer vision to perceive objects and robotics to move them. Again, the issue of acting like a human comes up primarily when artificial intelligence programs have to interact with people, as when expert system explains how it came to its diagnosis, or a natural language processing system has a dialogue with a user. These programs must behave according to certain normal covertness of human interaction in order to make them understood. The Turing test shows that machines can interact with human beings the way human beings interact amongst themselves. That is to say that machine can behave the way the human beings do.

ii) Thinking Humanly: The Cognitive Modeling Approach

The interdisciplinary field of cognitive science brings together computer models from Artificial Intelligence and experimental techniques from cognitive psychology to try to construct precise and testable theories of the workings of the human mind. And if we are going to say that a given program thinks like a human being, we must have some way of determining how human beings think. For that, we need to get inside the actual workings of the human mind. Stuart Russell and Peter Norvig say that there are two ways to do this: through introspection–trying to catch our own thoughts as they go by –or through psychological experiments. Once we have a sufficiently precise theory of the mind, it becomes possible to express the theory as a computer program. If the program’s input/output and timing behavior matches human behaviour, that is evidence that some of the program’s mechanisms may also be operating in humans.

Now it is almost taken for granted by many psychologists that a cognitive theory should be like a computer program. But we know that cognitive science is the science of mind. Therefore cognitive scientists seek to understand perceiving, thinking, remembering, understanding language, learning and other mental phenomenon. Their research is remarkably diverse, ranging from observing children's mental operation, through programming computers to do complex problem solving, to analyze the nature of meaning. In order to appreciate the work in artificial intelligence, which is a necessary part of cognitive science, it is necessary to have some familiarity with theories of human intelligence. The cognitive scientists introduce the notion of machine intelligence and emphasize the relationship between human and machine intelligence. The aim of artificial intelligence is to develop and test computer programs that exhibit characteristic of human intelligence. The most fundamental contribution of symbolic computational modeling has been the physical symbol system hypothesis. According to Newell and Simon, a physical symbol system has the necessary and sufficient means for general intelligent action. By 'necessary' we mean that any system that exhibits general intelligence will prove upon analysis to be a physical symbol system. By 'sufficient' we mean that any physical symbol system of sufficient size can be organized further to exhibit general intelligence. Lastly, by 'general intelligent action' we wish to indicate the same scope of intelligence as we see in human action; that in any real situation behaviour appropriate to the events of the system and adaptive to the demands of the environment can occur within some limits.

However, the ability of computer simulations to model such process is interpreted as a proof of the broader claim that a symbol system is at the center of human intelligence. In this hypothesis it shows that intelligence is an essential aspect of machines. If the machines have the capacity of intelligence, intelligence is the essence of human cognitions. Therefore, machines have cognitive capacity like the human beings. In the cognitive modeling approach, thus, human beings and machines show the property of being intelligent.

iii) Thinking Rationally: The Laws of Thought Approach

"Right thinking" is the inferential character of every reasoning process. Aristotle in his famous syllogisms provided patterns of argument structures that always give correct conclusions from given correct premises. In the syllogisms, the Laws of Thought play a vital role because these give law the right explanation of a syllogistic inference. There are three Laws of Thought recognized by the logicians. These have traditionally been called the law of Identity, the law of Contradiction, and the law of Excluded–Middle. These Laws of Thought are appropriate to different contexts. The formulations appropriate as follows:

a) The law of Identity asserts that *if any statement is true, then it is true*. This law asserts that every statement of the form P P is true, and that every such statement is a tautology.

b) The law of Contradiction asserts that *no statement can be both true and false*. This law asserts that every statement of the form P . ~P is false, that is, every such statement is self-contradictory, and its negation is logically true.

c) The law of Excluded-Middle asserts that *any statement is either true or false*. This law asserts that every statement of the form P ∨ ~P is true, that is, every such statement is a tautology.

In the 'Laws of Thought' approach to artificial intelligence, the whole emphasis is on correct syllogistic inferences. For example-

"Socrates is a man;

All men are mortal;

Therefore, Socrates is mortal."

In this inference, the conclusion is based on the premises according to the rules of inference. The above syllogistic inference is the best example to formulate an AI program. In all reasoning of this type the emphasis is on the logical inference of a conclusion from the premises. In the AI programme this type of logical inference is of much use since this programme provides a variety of logical reasoning. In an inference, a set of variables, a set of constant terms, a set of functions, the set of connectives *if, and, or,* and, *not,* the quantifiers '*exists'* and '*for all'* are the most important symbols to build an AI program. All these constants and variables are the arbitrary representations of the world. With the help of these symbols, the so-called logistic tradition within artificial intelligence hopes to build on such programs to create intelligent systems.[17]

iv) Acting Rationally: The Rational Agent Approach

Here, the word 'agent' refers to mechanical agent (computer). Acting rationally means acting so as to achieve one's goal, given one's beliefs. An agent (mechanical) is something that perceives and acts. Stuart Russell and Peter Norvig point out that making correct inferences is a part of being a rational agent because one way to act rationally is to reason logically to the conclusion that a given action will achieve one's goals, and then to act on that conclusion.

According to them, the study of artificial intelligence as rational agent design therefore has two advantages. First, it is more general than the 'laws of thought' approach, because correct inference is only a useful mechanism for achieving rationality, and not a necessary one. Second, it is more amenable to the scientific development than approaches based on human behavior or human thought, because the standard of rationality is clearly defined and completely general. As we have seen, an agent is something that perceives and acts in an environment. The job of artificial intelligence is to design the agent program, that is a function that implements the agent mapping from percepts to action. We assume this program will run on some sort of computing device A human agent has eyes, ears, and other organs for sensors, and hands, legs, mouth and other body parts for effectors. The relationship among agents, architectures, and programs can be summed up as:

Agent = Architecture + Program.

The agent is autonomous to the extent that its behaviour is determined by its own experience. A truly autonomous intelligent agent should be able to operate successfully in a wide variety of environments, given sufficient time and scope. But before we design an agent, we must have a pretty good idea of the possible percepts and actions, the agent's goal is supposed to achieve, and what sort of environment it will operate in it.

Again, as we have mentioned, an agent is just something that perceives and acts. In this approach, artificial intelligence is viewed as the study and construction of a rational agent. One of the important factors is that correct inference is not the whole of rationality. There are also ways of acting rationally that cannot reasonably be said to involve inference. For example, pulling one's hand off a hot stone is a reflex action that is more successful than a slower action taken after careful deliberation.

1.3 THE FIELD OF ARTIFICIAL INTELLIGENCE

Artificial intelligence is a new research area of growing interdisciplinary interest and practical importance. People with widely varying backgrounds and professional knowledge are contributing new ideas and introducing new tools into this discipline. Cognitive minded psychologists have developed new models of the mind based on the fundamental concepts of artificial intelligence, symbols systems and information processing. Linguists are also interested in these basic notions while developing different models in computational linguistics. And philosophers, in considering the progress, problems and potential of this work towards non-human intelligence, have sometimes found solution to the age-old problems of the nature of mind and knowledge. However, we know that artificial intelligence is a part of computer science in which are designed intelligent systems that exhibit the characteristics we associate with intelligence in human behaviour, understanding language learning, reasoning, problem solving, and so on. It is believed that insights into the nature of the mind can be gained by studying the operation of such systems. Artificial intelligence researchers have invented dozens of programming techniques that support some sort of intelligent behaviour.

Now the question is: Is artificial intelligence a science or an Art? According to Tanimoto, the activity of developing intelligent computer systems employs both proved mathematical principles, empirical results of studying previous system, and heuristic, pragmatic programming techniques. Information stored in rational data structures can be manipulated by well–studied techniques of computer science such as tree searching algorithms. At the same, experimental or vaguely understood 'rules of thumb' for problem solving are often crucial to the success of a system and must be carefully accommodated in intelligent systems. Thus artificial intelligence is both an art and a science. It is a science because it develops intelligent computer systems by employing proved mathematical principles. It is an art because it designs systems by employing programming techniques. Information stored in relational data structure can be manipulated by well-studied techniques of computer science such as tree searching diagram. Thus, the field of artificial intelligence is fascinating because of this complementing of art and science.

Artificial intelligence research may have impact on science and technology in the following way:

i) It can solve some difficult problems in chemistry, biology, geology, engineering and medicine.

ii) It can manipulate robotic devices to perform some useful, repetitive, sensory-motor tasks;

Besides, artificial intelligence researchers investigate different kinds of computation and different ways of describing computation in an effort not just to create intelligent artefacts, but also to understand what intelligence is. According to Charniak and McDermott, their basic tenet is to create computers which think.

Thus AI expands the field of intelligent activity of human beings in various ways. Now the question is: What would the world be like if we had intelligent machines? What would the existence of such machines say about the nature of human beings and their relation to the world around them? These questions have raised profound philosophical issues which will be discussed in due course.

The hypothesis of artificial intelligence and its corollaries are empirical in nature whose truth or falsity is to be determined by experiment and empirical test. The method of testing the results of artificial intelligence is of the following types:

i) In the narrow sense, artificial intelligence is part of computer science, aimed at exploring the range of tasks over which computers can be programmed to behave intelligently. Thus it is the study of the ways computers can be made to perform cognitive tasks, which generally human beings undertake.

ii) In the wider sense, artificial intelligence is aimed at programs that simulate the actual processes that human beings undergo in their intelligent behaviour. And these simulation programs are intended as theories describing and explaining human performance. But they are tested by comparing the computer output with the human behavior to determine whether both the result and also the actual behavior of computers and persons are closely similar.

A digital computer is an example of a physical symbol system, a system that is capable of inputting, outputting, storing, etc., following different courses of operation. These systems are capable of producing intelligence depending on the level of mechanical sophistication they are. The computers with these capabilities behave intelligently like human beings, according to the AI researchers.

One of the important tenets of cognitive science is that it stresses the relationship between human and machine intelligence. It is interested in using artificial intelligence techniques to enlighten us about how human beings do intelligent tasks.[24] For example, in getting a machine to solve geometric or integral calculus problems, we are also interested in learning more about the power and flexibility of the human capacity for problem solving. Thus, the AI researcher attempts to develop and test computer programs that exhibit characteristics of human intelligence. The AI researcher always works with an artifact, which is only inferentially related to the human mind. As Boden says, The ‘machines’ in question are typically digital computers, but artificial intelligence is not the study of computers. But it is the study of intelligence in thought and action. Moreover, as Bonnet would say, artificial intelligence is the discipline that aims to understand the nature of human intelligence through the construction of computer programs that imitate intelligent behaviour.

Further, Bonnet says, we cannot define human intelligence in general we can highlight a number of criteria by which it can be judged, such as the ability to make abstractions or generalizations, to draw analogies between different situations and to adopt new ones, to detect and correct mistakes in order to improve future performance, and so on. AI is concerned with the intelligent properties of the computational systems, which perform many intelligent tasks. These tasks can be of very varied nature, such as, the understanding of a spoken or written text in a natural language, playing chess, solving a puzzle, writing a poem, making a medical diagnosis, finding one's way from Hyderabad to Delhi. The AI programme selects such activities include information and reasoning processes which are part of any intelligent system.

Artificial intelligence includes commonsensical tasks, such as understanding English language, recognizing scenes, finding a way to reach an object that is far overhead, heavy and frigid, and making sense of the plot of a mystery novel. In addition, artificial intelligence includes expert tasks, such as diagnosing diseases, designing computer systems, locating mineral deposits, and planning scientific experiments. The techniques that artificial intelligence applies to solve these problems are representation and inference methods for handling the relevant knowledge, and search based problem-solving methods for exploiting that knowledge. Although the tasks with which artificial intelligence is concerned may seem to form a very heterogeneous set, in fact, they are related through their common reliance on techniques for manipulation of knowledge and conducting search which we will discuss in the next section.

1.4 WHAT COMPUTERS CAN DO

Within the scientific discipline of artificial intelligence, there are several distinct areas of research, each with its own specific interests, research techniques, and terminology. However, as Avron Barr and Edward A. Feigenbaum point out, artificial intelligence is part of computer science concerned with designing intelligent computer systems, that is, systems that exhibit the characteristics we associate with intelligence in human behavior such as understanding language, learning, reasoning, solving problems and so on.

In artificial intelligence, this specialization includes research on language understanding, automatic programming, and several others. The following discussion of the status of artificial intelligence attempts to show the sub–fields identifying some aspects of intelligent behaviours and indicating the state of relevant research. Like the different sub–fields of artificial intelligence, the different behaviours discussed here are not at all independent; separating them out is just a convenient way of indicating what current artificial intelligence programs can do.

i) Problem Solving

The first big successes in artificial intelligence were programs that could solve puzzles and play games like chess. Techniques like looking ahead several moves and dividing difficult problems into easier sub-problems evolved in the fundamental artificial intelligence techniques of search and problem reduction. Another problem solving program that integrates mathematical formulas symbolically has attained very high level of performance and is being used by scientists and engineers. According to Avron Barr and Edward A. Feigenbaum, human beings often solve a problem by finding a way of thinking about it that makes the solution easy, but so far, artificial intelligence programs must be told how to think about the problems they solve.

Elaine Rich defines problem solving, as that which chooses the best technique(s) and applies it (them) to the particular problem. Another view is that a goal and a set of means of achieving the goal are called a problem solving. Before an agent can start searching for solutions, it must formulate a goal and then use the goal to formulate a problem. According to Stuart Russell and Peter Norvig, a problem consists of four parts. The initial state, a set of operators, a goal test function, and a path cost function. The environment of the problem is represented by a state space. A path through the state space from the initial state to a goal state is a solution. And a search can be judged on the basis of completeness, optimality, time complexity, and space complexity. There are different search paths for an intelligent agent. The agent has to search which is the minimum path to reach the goal. To solve a problem is the main task of the agent in artificial intelligence.

Moreover, one of the important searches in artificial intelligence is the technique of 'heuristic' search. The word 'heuristic' is derived form the Greek verb '*heuriskein'*, meaning 'to find' or 'to discover'. Some people use heuristic as the opposite of algorithmic. According to Newell, Shaw and Simon, process that may solve a given problem, but offers no guarantees of doing so is called a heuristic for that problem.We know that heuristic techniques dominated early application of artificial intelligence. Heuristic method is still used in problem solving. For example, game playing is also a form of problem solving. Games have engaged the intellectual faculties of the humans. And game playing is also one of the oldest areas of endeavour in artificial intelligence. A chess-playing computer is a proof of a machine doing something though intelligence. Furthermore, the simplicity of the rules and their application in the program implies that it is easy to represent the game as a search through a space of possible game positions.

The initial state, the operators, a terminal test, and a pay-off function can define a game. According to Carpenter and Just, an intelligent machine can follow all these rules and play more efficiently than human beings. For example, in speed chess, computers have defeated the world champion, Gary Kosparov, in both five-minutes and twenty five minutes games. Such a system would be a significant achievement not just for game playing research, but also for artificial intelligence research in general, because it would be much more likely to be applied to the problem faced by a general intelligent agent. There are so many kinds of search in order to solve a problem. But we are not explaining the entire search. We are mainly concerned with how artificial intelligence programs solve different problems within a few seconds.

ii) Natural Language Processing

The most common way that people communicate is by speaking or writing in one of the natural languages like, Hindi, English, French or Chinese. However, the computer-programming language seems to differ from human languages. These 'artificial' languages are designed so that sentences have a rigid format, or syntax, making it easier for compliers to phrase the programs and convert them into the proper sequences of computer instructions. Besides, being structurally simpler than natural language, programming language can easily express only those concepts that are important in programming: 'Do this, then do that', 'See whether such and such is true'.

One of the important facts is that if computers could understand what people mean when people use English language, the systems would be easier to use and would fit more naturally into people's lives. Artificial intelligence researchers hope that learning how to build computers that can communicate as people do would extend our understanding of human language and mind. The goal of cognitive linguistics is to specify a theory of language comprehension and production to such a level of detail that a person could write a computer program that could understand and produce natural language. Thus, the intelligent machine program has the capacity to understand natural language. It also responds to questions in an appropriate manner. Thus, if the question were 'Is Rome the capital of France?' the simple reply 'No' would be appropriate but, 'no, it is Paris,' or, 'No, Rome is the capital of Italy' would be more complex. Machine programs would also be able to explain the meaning of the word in other terms and also to translate from one language to another.

iii) Machine Vision

Vision is the information processing of understanding a scene from its projected images. An image is a two-dimensional function (X, Y) obtained, with a sensing device that records the value of an image feature at all points (X, Y). Images are converted into a digital form for processing with a computer. The task of a computer-vision system is to understand the scene that an imaginary of pixels depicts. Generally, machine vision means the vision of a machine that can see or perceive the things in the world. According to David Marr, vision is the process of discovering form images what is present in the world, and where it is. Thus, vision is, first and foremost, an information-processing task. Moreover, there is a distinction between human vision (perception) and machine vision, because human vision is defined as the eye is just a sensor; the visual cortex of the human brain is our primary organ of vision. In the case of human vision, the sensory organ necessarily forms a representation or physical encoding of the received information that facilitates the answering of some questions about the environment, but makes it extremely difficult to answer others. For example, an examination of the encoded information produced by the human eye reveals that at any instant of time the eye has sensed only a small part of the electromagnetic spectrum, and has extracted an image of the scene from a particular viewpoint in space. It possesses the visual information with the help of the lens fitted within it. Thus machine vision works more or less like human vision.

Learning is now perceived as a gateway to understanding the problem of intelligence. Because seeing is also intelligence, seeing is also learning which is a key to the study of intelligence and biological vision. Visual neuroscience develops the methods of understanding how human visual systems work. Visual neuroscience is beginning to focus on the mechanisms that allow the cortex to adapt its circuitry and learn a new task. Machine vision as a part of the AI programme, however, tries to develop systems that can simulate human vision.

iv) Machine Learning

Learning for an intelligent agent is essential for dealing with unfamiliar environments. Learning a function from examples of its input and output is called inductive reasoning. According to Bonnet, the ability to learn is one of the fundamental constituents of intelligence, 'learning' being understood in its general sense as indicating the way in which the humans and animals can increase their stock of knowledge and improve their skill and reasoning powers.

Moreover, from the very beginning of artificial intelligence, researchers have sought to understand the process of learning and to create computer programs that show learning behaviour. Ordinarily, learning is a very general term denoting the way in which people increase their knowledge and improve their skills. There are two fundamental reasons for studying learning. One is to understand the process itself. By developing computer models of learning, psychologists have attempted to gain an understanding of the way humans learn. Philosophers since Plato have also been interested in the process of learning, because it might help them understand and know what knowledge is and how it grows.

The second reason for learning research is to provide computers with the ability to learn. Learning research has potential for extending the range of problems to which computers can be applied. In particular, the work in machine learning is important for expert systems development, problem solving, computer vision, speech understating, conceptual analysis of databases, and intelligent authoring systems. In this way, a computer can do more work than human beings. According to James R. Slagle, computers can do arithmetic at an unbelievable speed, and no human can compete with them. Besides, computers can do many other odd jobs like detecting a certain disease from the available data.

1.5 LET US SUM UP

Thus, AI as a study of machine intelligence, especially of computers and robots, opens up new vistas of understanding mind and intelligence. Intelligent behaviour can be studied in many dimensions. This is made possible by the invention of computers as high-processing computing machines. The computers can do many things that seem to require intelligence and other mental abilities.

1.6 KEY WORDS

Artificial Intelligence, Turing Machine, and Physical Symbol System

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