Module 1

CHAPTER 1

Introduction to Artificial Intelligence

Syllabus

Introduction, History of Artificial Intelligence, Intelligent Systems: Categorization of Intelligent System, Components of AI Program, Foundations of AI, Sub-areas of AI, Applications of AI, Current trends in AI.

1.1 INTRODUCTION

The field of Artificial Intelligence (AI) and Machine Learning (ML) has exploded in last decade. The roots of these words originate from multiple disciplines and not just computer science.

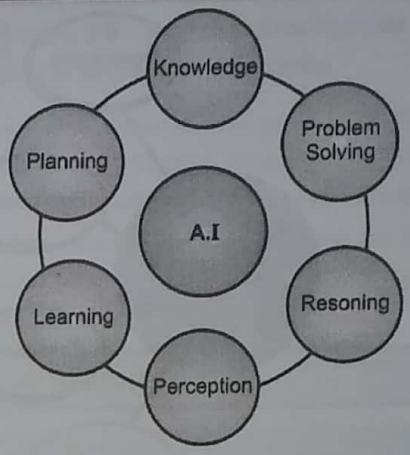
These disciplines include pure mathematics, electrical engineering, statistics, signal processing, and communications along with computer science to name the top few.

Along with the wide variety of origins, the field also finds applications in even greater number of industries ranging from high-tech applications like image processing, natural language processing to online shopping to non-destructive testing of nuclear power plants and so on.

1.1.1 What is AI ?

GQ. What is Artificial Intelligence?

- Alan Turing **defined Artificial Intelligence** as follows: "If there is a machine behind a curtain and a human is interacting with it (by whatever means, e.g. audio or via typing etc.) and if the human feels like he/she is interacting with another human, then the machine is artificially intelligent."
- There are two aspects to AI as viewed from human-like behavior standpoint. One is where the **machine is intelligent** and is **capable of communication with humans**, but does not have any locomotive aspects. The other aspect involves having physical interactions with human-like locomotion capabilities, which refers to the field of robotics.
- Artificial intelligence (AI, also machine intelligence, MI) is intelligence demonstrated by machines, in contrast to the natural intelligence (NI) displayed by humans and other animals. The term "artificial intelligence" is applied when a machine mimics "cognitive" functions that humans associate with other human minds, such as "learning" and "problem solving".
- We can use AI in many special domains and functions like understanding/learning, Planning, Problem solving, Decision making (Fig. 1.1.1). These all are very helpful now days in various industries.



(1A1)**Fig. 1.1.1 : Different phases under AI**

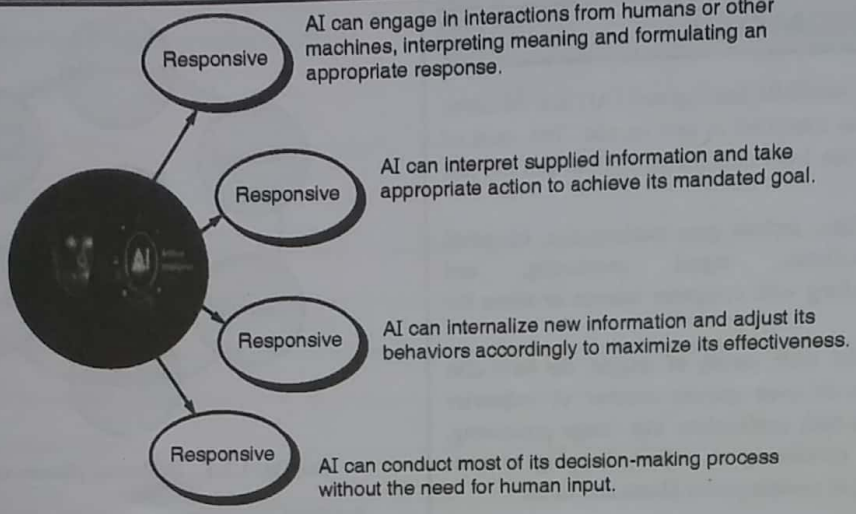
Artificial Intelligence is a term, which consists of two words.

1.1.1.1 Artificial

- Artificial is somewhat that is not real and is simulated. Artificial is not only used in the context of food. Artificial turf is a grass like surface used for sports playing fields.
- Artificial diamonds are those that are manufactured, as opposed to those that have developed through natural processes in the earth. Artificial flowers are often used as decorations.

1.1.1.2 Intelligence

- Defining and classifying intelligence is extremely complicated. Theories of intelligence range from having one general intelligence, to certain primary mental abilities, and to multiple category-specific intelligences.
- Intelligence is defined in many different ways like logic, understanding, self-awareness, learning, emotional knowledge, planning, creativity and problem solving.
- Day by day lot of innovations takes place in today's world. New technologies, new machines with greater efficiency performances are the need of upcoming Techies and this thing is growing gradually exponentially.



(1A2)**Fig. 1.1.2 : Artificial Intelligence**

- Tremendous efforts in every domain has to be carried out as a need of future world that may be faster processing speed, reducing memory overhead lesser in size and more intelligent.
- Now the question arises, can we make machine intelligent? Answer is a Yes and this has been possible because of AI (Artificial Intelligence).
- As a result of this, we can make the system, and train the system build the system which can mimic the behavior and multiple properties and function of human being.

1.1.2 Objectives of AI

GQ. What are different objectives of AI ?

Below are the eight aims and objectives of artificial intelligence :

☞ Objective #1 : Artificial intelligence solves problems

- When it comes to artificial intelligence, there is a strong urge to create AI programs that look, act, and feel like real humans.
- However, many scientists now understand that the real goal is not to make a human-like robot. Instead, they would rather create a robot that works to make our lives easier, no matter what it looks or sounds like.
- Moving forward, it is likely that we will see some serious work being put into the ability for AI to learn and understand, and less on forcing them to act like real humans. That will probably just come with time.

☞ Objective #2 : Artificial intelligence completes multiple tasks

- Completing multiple tasks is another aims and objectives of artificial intelligence. One of the largest difficulties to overcome has been making it possible for an AI program or a "robot" to do more than one task. It is very easy to program a system to complete a certain task. For instance, it can bring an item from point A to point B.
- However, if you want the program to understand that it must pick up the item and then either bring it to point A or throw it in the trash based on arbitrary rules that a human would know that's a different story. In simpler terms, it might be a while before your housemaid is a robot.

☞ Objective #3 : Artificial intelligence shapes the future of every company

- AI is quickly becoming a crucial tool for all companies. They are using this technology to streamline their processes.
- It's no secret that the goal is to continue this trend for as many low-level tasks as possible. It ultimately saves the companies money in the long run, and it allows them to up productivity in other areas.

☞ Objective #4 : Artificial intelligence prepares for a boom in big data

- Big data has already taken the world by storm. Big data is the large-scale, and sometimes even random, collection of data about people's lives, habits, conversations and more.

- AI will be able to do much more for the analysis of this data than humans ever did, so data-driven research, advertisements, and content are going to explode.

☞ Objective #5 : Artificial intelligence creates synergy between humans and AI

One of the key goals in AI is to develop a strong synergy between AI and humans, so that they can work together to enhance the capabilities of both.

☞ Objective #6 : Artificial intelligence is good at problem-solving

So far, AI is unable to employ advanced problem-solving abilities. That is, it can tell you a factual answer, but cannot analyze a specific situation and make a decision based on the very specific context of that situation.

☞ Objective #7 : Artificial intelligence helps with planning

One of the most human traits in existence is the ability to plan and make goals and subsequently accomplish them. And one of the goals for AI is to have AI be able to do these things.

☞ Objective #8 : Artificial intelligence performs more complex tasks

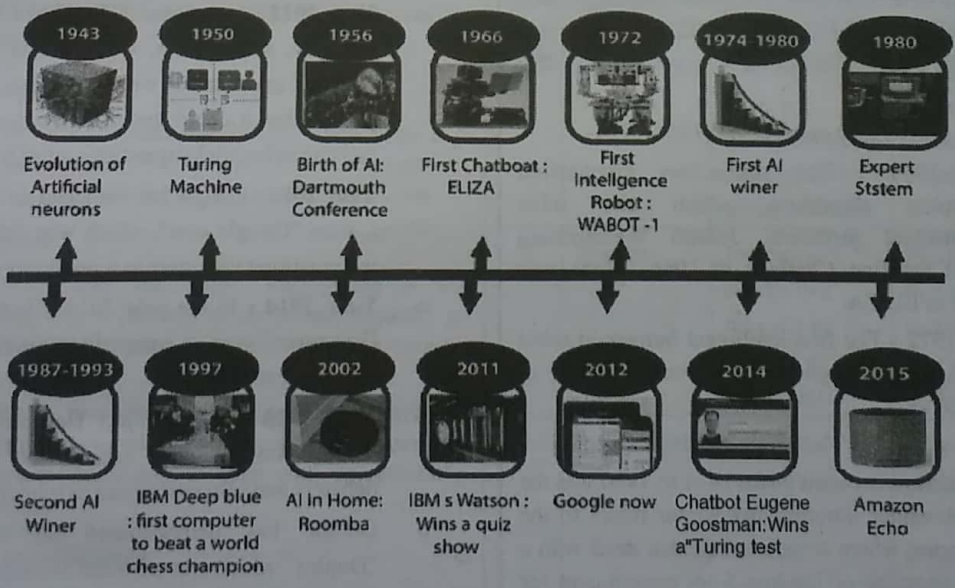
- The key goal is this: to develop AI programs that can complete more and more complex tasks. Already the abilities are shocking, although not yet widespread.
- However, over time these will develop and ultimately, scientists hope, be able to do basically the same things humans can do.

⏭ 1.2 HISTORY OF AI

GQ. Write a short note on : History of Artificial Intelligence ?

Artificial Intelligence is much older than you would imagine. Even there are the myths of Mechanical men in Ancient Greek and Egyptian Myths.

Following are some milestones in the history of AI which defines the journey from the AI generation to till date development.



(1A4)**Fig. 1.2.1 History of AI**

- Maturation of Artificial Intelligence (1943-1952)
  - **Year 1943 :** The first work which is now recognized as AI was done by Warren McCulloch and Walter pits in 1943. They proposed a model of **artificial neurons**.
  - **Year 1949 :** Donald Hebb demonstrated an updating rule for modifying the connection strength between neurons. His rule is now called **Hebbian learning**.
  - **Year 1950 :** The Alan Turing who was an English mathematician and pioneered Machine learning in 1950. Alan Turing publishes **"Computing Machinery and Intelligence"** in which he proposed a test. The test can check the machine's ability to exhibit intelligent behavior equivalent to human intelligence, called a **Turing test**.
- The birth of Artificial Intelligence (1952-1956)
  - **Year 1955 :** An Allen Newell and Herbert A. Simon created the "first artificial intelligence program "Which was named as **"Logic Theorist"**. This program had proved 38 of 52 Mathematics theorems, and find new and more elegant proofs for some theorems.
  - **Year 1956 :** The word "Artificial Intelligence" first adopted by American Computer scientist John McCarthy at the Dartmouth Conference. For the first time, AI coined as an academic field.
  - At that time high-level computer languages such as FORTRAN, LISP, or COBOL were invented. And the enthusiasm for AI was very high at that time.
- The golden years-Early enthusiasm (1956-1974)
  - **Year 1966 :** The researchers emphasized developing algorithms which can solve mathematical problems. Joseph Weizenbaum created the first Chatbots in 1966, which was named as ELIZA.
  - **Year 1972 :** The first intelligent humanoid robot was built in Japan which was named as WABOT-1.
- The first AI winter (1974-1980)
  - The duration between years 1974 to 1980 was the first AI winter duration. AI winter refers to the time period where computer scientist dealt with a severe shortage of funding from government for AI researches.
  - During AI winters, an interest of publicity on artificial intelligence was decreased.
- A boom of AI (1980-1987)
  - **Year 1980 :** After AI winter duration, AI came back with "Expert System". Expert systems were programmed that emulate the decision-making ability of a human expert.
  - In the Year 1980, the first national conference of the American Association of Artificial Intelligence was held at Stanford University.
- The second AI winter (1987-1993)
  - The duration between the years 1987 to 1993 was the second AI Winter duration.
  - Again Investors and government stopped in funding for AI research as due to high cost but not efficient result. The expert system such as XCON was very cost effective.
- The emergence of intelligent agents (1993-2011)
  - **Year 1997 :** In the year 1997, IBM Deep Blue beats world chess champion, Gary Kasparov, and became the first computer to beat a world chess champion.
  - **Year 2002 :** for the first time, AI entered the home in the form of Roomba, a vacuum cleaner.
  - **Year 2006 :** AI came in the Business world till the year 2006. Companies like Facebook, Twitter, and Netflix also started using AI.
- Deep learning, big data and artificial general intelligence (2011-present)
  - **Year 2011 :** In the year 2011, IBM's Watson won jeopardy, a quiz show, where it had to solve the complex questions as well as riddles. Watson had proved that it could understand natural language and can solve tricky questions quickly.
  - **Year 2012 :** Google has launched an Android app feature "Google now", which was able to provide information to the user as a prediction.
  - **Year 2014 :** In the year 2014, Chatbot "Eugene Goostman" won a competition in the infamous "Turing test."
  - **Year 2018 :** The "Project Debater" from IBM debated on complex topics with two master debaters and also performed extremely well.
  - Google has demonstrated an AI program "Duplex" which was a virtual assistant and which had taken hairdresser appointment on call, and lady on other side didn't notice that she was talking with the machine.

- Now AI has developed to a remarkable level. The concept of Deep learning, big data, and data science are now trending like a boom. Nowadays companies like Google, Facebook, IBM, and Amazon are working with AI and creating amazing devices. The future of Artificial Intelligence is inspiring and will come with high intelligence.

1.3 INFORMATION, KNOWLEDGE AND INTELLIGENCE

GQ. Define information, knowledge and intelligence. What is the comparison between artificial and human intelligence.

GQ. Explain Intelligence and Artificial Intelligence. How does conventional computing differ from the intelligence computing?

(1) Information

- All data are information. However, there is some part of information that is not considered as a data. Such **distinguished information** can be considered as a processed data, which makes decision making easier. Processing involves an **aggregation** of data, **calculations** of data, **corrections** on data, etc. in such a way that it generates the flow of messages.
- Information usually has some meaning and purpose that is; data within a context can be considered as information.

(2) Knowledge

Knowledge is a justified true belief. Knowledge is a **store of information** proven useful for a capacity to act.

(3) Intelligence

- Unlike belief and knowledge, intelligence is not information: it is a process, or an **innate capacity to use information** in order to respond to ever-changing requirements.
- It is a capacity to **acquire, adapt, modify, extend** and **use information** in order to solve problems. Therefore, intelligence is the ability to cope with unpredictable circumstances.

(A) Human intelligence

- Human intelligence is the intellectual capacity of humans, which is characterized by perception, consciousness, self-awareness, and volition.
- Intelligence enables humans to remember description of things and use those descriptions in future behaviours. It is a **cognitive process**.
- It gives humans the cognitive abilities to learn from concepts, understand, and reason, including the capacities to recognize patterns, comprehend ideas, plan, solve problems, and use language to communicate. Intelligence enables humans to experience and think.

(B) Artificial intelligence

- Artificial intelligence (or AI) is both the intelligence of machines and the branch of computer science which aims to create it, through "the study and design of intelligent agents" or "rational agents", whereas; an intelligence agent is a system that perceives its environment and takes actions which maximize its chances of success.
- Achievements in artificial intelligence include constrained and well-defined problems such as **games, crossword-solving and optical character recognition** and a few more general problems such as **autonomous cars**. General intelligence or strong AI has not yet been achieved and is a long-term goal of AI research.

1.3.1 Differences between Conventional Computing and Intelligence Computing

Sr. No.	Parameters	Intelligence computing	Conventional computing
1.	Solution	Does not guarantee a solution to a given problem.	Guarantees a solution to a given problem.
2.	Results	Produces results that may not be reliable or consistent.	Produces results that are consistent and reliable.
3.	Instructions	Solves the problem without specific program instructions.	Solves the given problem according to the programmer's exact instructions (algorithm).

1.4 AI TECHNIQUES

(1) An artificial intelligence technique is a method that exploits knowledge that is represented so that, the knowledge captures generalizations and situations that share properties which can be grouped together, rather than being allowed in a separate representation. It can be understood by people who must provide the knowledge; although for many programs the bulk of the data may come automatically, such as from readings.

(2) There are various techniques that have evolved and can be applied to a variety of artificial intelligence tasks. These techniques are concerned with how we represent, manipulate and reason with knowledge in order to solve problems.

(3) In short AI technique is a manner to organize and use the knowledge efficiently in such a way that –

- It should be perceivable by the people who provide it.
- It should be easily modifiable to correct errors.
- It should be useful in many situations though it is incomplete or inaccurate.

(4) AI techniques elevate the speed of execution of the complex program it is equipped with.

Following are three important artificial intelligence techniques

- **Search :** Provides a way of solving problems for which no more direct approach is available.
- **Use of knowledge :** Provides a way of solving **complex problems** by exploiting the structures of the objects that are involved.
- **Abstraction :** Provides a way of separating important features and variations from many unimportant ones that would otherwise overwhelm any process.

(1) **Knowledge representation :** Knowledge representation is crucial. One of the clearest results of artificial intelligence research so far is that; solving even apparently simple problems requires lots of knowledge. Really understanding a single sentence requires extensive knowledge of both language and the context. Really understanding a visual scene similarly requires knowledge of the kinds of objects in the scene. Solving problems in a particular domain generally requires knowledge of the objects in the domain and knowledge of how to reason in that domain. Both these types of knowledge must be represented efficiently, and in a meaningful way.

(2) **Efficiency :** It is important, as it would be impossible (or at least impractical) to explicitly represent every fact that we might ever need.

(3) **Search :** Another crucial general technique required while writing an artificial intelligence programs is a search. Often there is no direct way to find a solution to some problem. However, we know how to generate possibilities.

- **For example**, in solving a puzzle you might know all the possible moves, but not the sequence that would lead to a solution. When working out how to get somewhere one might know all the roads/buses/trains, just not the best route to get our destination quickly. Developing good ways to search through these possibilities for a good solution is therefore vital.
- **Brute force techniques**- where we generate and try out every possible solution that may work, but are often very inefficient, as there are just too many possibilities to try.
- **Heuristic techniques** are often better, where we only try the options, which we think (based on our current best guess) are most likely to lead to a good solution.

1.5 INTELLIGENT SYSTEM (IS)

(1) **Intelligent System** (IS) can be defined as the **system** that incorporates intelligence into applications being handled by machines.

(2) **Intelligent systems** perform search and optimization along with learning capabilities.

(3) Different types of machine learning such as supervised, unsupervised and reinforcement learning can be modeled in designing **intelligent systems**.

(4) **Intelligent systems** also perform complex automated tasks which are not possible by traditional computing paradigm.

(5) Various diagnostic, robotics and engineering **systems** are results of **intelligent** procedures implemented in **Intelligent System** Design.

1.5.1 Categorization of Intelligent Systems

Sr. No.	Intelligence	Description	Example
1.	Linguistic intelligence	The ability to speak, recognize, and use mechanisms of phonology (speech sounds), syntax (grammar), and semantics (meaning).	Narrators, Orators
2.	Musical intelligence	The ability to create, communicate with, and understand meanings made of sound, understanding of pitch, rhythm.	Musicians, Singers, Composers
3.	Logical-mathematical intelligence	The ability of use and understand relationships in the absence of action or objects. Understanding complex and abstract ideas.	Mathematicians, Scientists
4.	Spatial intelligence	The ability to perceive visual or spatial information, change it, and re-create visual images without reference to the objects, construct 3D images, and to move and rotate them.	Map readers, Astronauts, Physicists
5.	Bodily-Kinesthetic intelligence	The ability to use complete or part of the body to solve problems or fashion products, control over fine and coarse motor skills, and manipulate the objects.	Players, Dancers
6.	Intra-personal intelligence	The ability to distinguish among one's own feelings, intentions, and motivations.	Gautam Buddhha
7.	Interpersonal intelligence	The ability to recognize and make distinctions among other people's feelings, beliefs, and intentions.	Mass Communicators, Interviewers

You can say a machine or a system is **artificially intelligent** when it is equipped with at least one and at most all intelligences in it.

1.6 DIFFERENT DEFINITIONS OF ARTIFICIAL INTELLIGENCE

UQ. Explain different definitions of artificial intelligence according to different categories.
(MU - Q. 1(a), Dec. 19, 5 Marks)

(I) **Strong AI :** This concept was put forward by John Searle in 1980 in his article "Minds, Brains and programs". Strong form AI provides theories for developing some form of computer based AI that can truly reason and solve problems. A strong form of AI is said to be sentient or self-aware.

Strong AI can be categorized as :

1. Human-like AI-In which the computer program thinks and reasons much like a human-mind.
2. Non-human-like AI-IN which the computer program develops a totally nonhuman sentience, and a non-human way of thinking and reasoning.

(II) **Weak AI :** Weak artificial intelligence research deals with the creation of some form of computer-based AI that cannot truly reason and solve problems. They can reason and solve problems only in a limited domain, such a machine would, in some ways, act as if it were intelligent, but it would not possess true intelligence.

There are several fields of weak AI, one of which is natural language. Much of the work in this field has been done with computer simulations of intelligence based on predefined sets of rules. Very little progress has been made in strong AI. Depending on how one defines one's goals, a moderate amount of progress has been made in weak AI.

1.7 MAJOR COMPONENTS OF ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) refers "Developing computer programs to store complex problems by application of process that analogues to human reasoning."

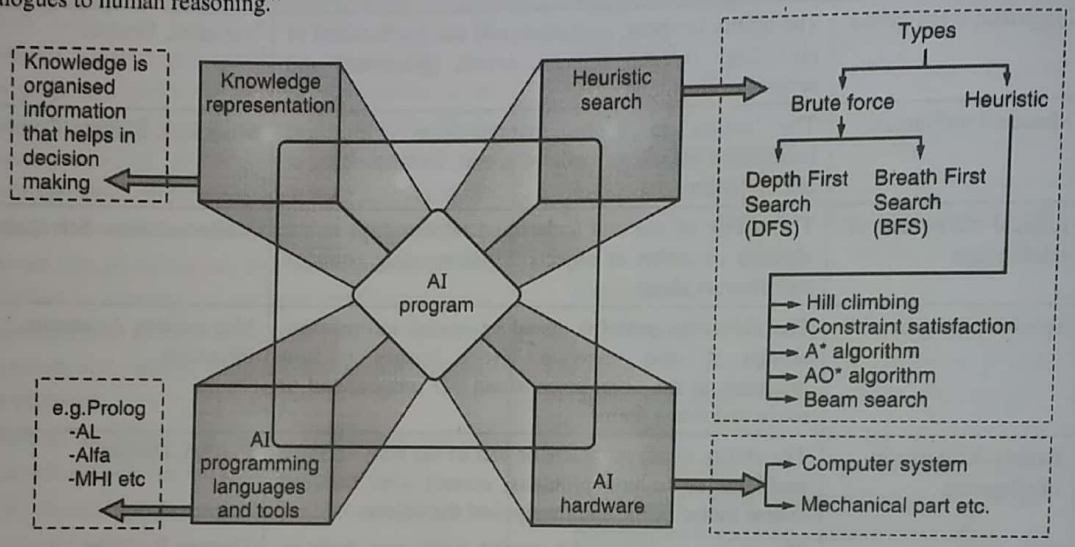


Fig. 1.7.1 : Major components of an AI system

- Any AI system has four major components :
  1. Knowledge representation.
  2. Heuristic search.
  3. AI programming languages and tool.
  4. AI hardware.
- **Definition :** Artificial intelligence (AI) refers to a **"Developing computer programs to store complex problems by application of process that analogues to human reasoning."** The quality of the results depends on how much knowledge the system possesses. The available knowledge must be represented in a very efficient way. Hence **knowledge representation** is a vital component of the system.
- It is not merely enough that knowledge is represented efficiently. The **inference process** should also be equally good for satisfactory results. The inference process is broadly divided into **brute and heuristic search procedures**.
- Today just like we have specialized languages and programs for data-processing and scientific applications, we encounter specialized languages and tools for AI programming. AI languages provide the basic functions for AI programming and tools for the right environment.
- Most of the AI programs are implemented on **Von Neumann machines** only. However, dedicated workstations have emerged for AI programming. AI provides details on the machine architecture for AI machines.

1.7.1 Functions of Each Components of AI System

(1) Knowledge Representation
(2) Heuristic Search
(3) AI programming Language and Tool
(4) AI Hardware

(1) Knowledge Representation

- Knowledge representation in AI describes the representation of knowledge. It expresses how the beliefs, intentions, and judgements of an intelligent agent can be expressed suitably for automated reasoning. One of the primary purposes is modelling intelligent behaviour for an agent.
- It represents information from the real world for a computer to understand and then utilise this knowledge to solve complex real-life problems, like communicating with human-beings in natural language.

- It stores data in a database, and allows a machine to learn from that knowledge and behave intelligently like a human being.

(2) Heuristic Search

- In mathematical optimisation and computer science, heuristic is a technique designed for solving a problem more quickly when classic methods fail to find any exact solution.
- This is achieved by trading optionality, completeness, accuracy, or precision for speed. In a way, it can be considered a short-cut.
- A heuristic function ranks alternatives in search algorithms at each balancing step based on available information to decide which branch to follow.

(3) AI programming Language and Tool

(i) Python

- Python language is the forerunner of all other languages. It uses simple syntax.
- The simple syntax allows to spend much more time on planning the core structure, which is why python is an ideal choice for machine learning processes.

(ii) Lisp

- It is the oldest language used for AI processes. Lisp is considered as a tool in AI with its enlarged scope of turning thoughts into reality.
- The language differentiates itself from other AI languages by eying precision.

(iii) R

- This is highly efficient programming language.
- Packages like G models, RODBC, one R and Tm allow huge support for machine learning processes.

(iv) Prolog

- It is completely designed by logic. Prolog requires three important factors : rules, facts and the desired result.
- Once these requirements are provided, the language will figure out the link between the three and design an AI solution.

(v) C++

- One of the major advantages of having C++ as programming language is its processing speed.
- To run complex automated solutions efficiently, C++ is very useful.

(vi) Javascript

- For versatility, Javascript is ahead of Java.
- With continuous developments, multiple domain growth, backend use, ease of use, efficiency etc. Support the above statement.

(vii) Java

- The best benefit of using the JAVA programming language is the presence of virtual machine technology.
- Java virtual machine eases the implementation process.

(viii) Haskell

- This programming language is well-known for resolving errors, during the compilation process and even before that.
- The features like build-in memory and code reusability increase the time allotted for planning the process.

(ix) Julia

- The programming language is well-known for numerical analysis.The best feature of Julia is dynamic type system, which allows you to use the language for literally any process.
- Other features involve in-built package manager, macro programming abilities, multiple dispatch support and suitability with C functions.

(4) AI Hardware

- An AI accelerator is a specialised hardware accelerator or computer system designed to accelerate AI and machine learning applications, including neural networks and machine vision.
- Applications include algorithms for robotics, internet of things and other data-intensive or sensor-driven tasks.

1.8 FOUNDATIONS OF AI

The foundation of AI does not occur in isolation. Fields such as philosophy, linguistics, psychophysics, and theoretical computer science have exercised a historical influence over the field and today there is much discussion over the new field of cognitive science. One consequence of discussion (or dialogue) is that the criticism of positions held in one discipline frequently applies to positions held in other disciplines.

Of these, five stand out as particularly fundamental.

(1) Pre-eminence of knowledge and conceptualisation
(2) Disembodiment
(3) Kinematics of cognition are language-like
(4) Learning can be added later
(5) Uniform architecture
(6) Are knowledge and conceptualisation at the heart of AI ?
(7) Linguistic concept
(8) The logicist concept of concept
(9) Inferential abilities
(10) Knowledge and perception
(11) Growth of knowledge

(1) Pre-eminence of knowledge and conceptualisation

Intelligence requires declarative knowledge and some form of reasoning like computation is called 'cognition'. Core AI is the study of the conceptualizations of the world presupposed and used by intelligent systems during cognition.

(2) Disembodiment

Cognition and knowledge it presupposes can be studied largely in abstraction from the details of perception and motor control.

(3) Kinematics of cognition are language-like

It is possible to describe the trajectory of knowledge states or informational states created during cognition using a vocabulary very much like English or some regimented logico-mathematical version of English.

(4) Learning can be added later

The kinematics of cognition and the domain knowledge needed for cognition can be studied separately from the study of concept learning, psychological development, and evolutionary change.

(5) Uniform architecture

There is a single architecture underlying virtually all cognition.

Remark : By 'cognition' is meant to refer to computational processes that resemble both reasoning in a classical sense and computational processes that are more 'peripheral' than reasoning, such as language recognition and object identification, where the representations are not about the entities and relations, but which may usefully be construed as rules operating on representations.

(6) Are knowledge and conceptualisation at the heart of AI ?

A theory in AI is a specification of the knowledge under planning a cognitive skill. A cognitive skill is the information - based control mechanism regarding performance in some domain. It is meant to cover information sensitive activities such as problem solving, language use, decision making, routine activity, perception and some elements of motor control.

(7) Linguistic concept

- In the case of linguistics and higher vision these basic knowledge units tend more generally to be about theoretical entities. Only occasionally will there be pre-existing terms in English for them. Thus, noun phrase, sphere, pyramid and other shapes are commonsense concepts having familiar English names, but governing domain, animate movements, causal launchings and most shape representations are, for most people, novel ideas that are not part of common parlance.
- The basic knowledge units of cognition the conceptualizations under planning cognitive skills-may range, from the familiar to the exotic and theoretical.
- The basic idea that knowledge and conceptualization lie at the heart of AI stems from the seductive view that cognition is inference. Intelligent skills are composed of two parts a declarative knowledge base and an inference engine.
- The inference engine is relatively uncomplicated; it is a domain-independent program that takes as input a set of statements about the current situation plan, a fragment of the declarative knowledge base, it produces as output a stream of knowledge - based programs.
- Logicists are not unmindful of the need to explain for a system to understand a proposition, or to grasp the concepts which constitute propositions. But the party line is that this job can be pursued independently from the designer's main task of inventing conceptualizations.
- The two activities inventing conceptualization and grounding concepts-are modular. Hence the grounding issue has not historically been treated as posing a challenge that might overturn the logicist program.

(8) The logicist concept of concept

- A concept is a modular component of knowledge. If we say that kishor knows 'the pen is on the desk', and we mean this to imply that kishor grasps the fact of their being a particular pen on a particular desk, we assume that he has distinct concepts for 'pen', 'desk' and 'on'.

- We assume this because we believe that kishor must know what it is for something to be a pen, a desk, and something to be an something else.
- If concepts and conceptual schemes seem to play enough of an explanatory role at the disembodied level to be seen as robust entities, then we can study their structure without concern for their grounding.

(9) Inferential abilities

- It is the capacity of an agent to draw inferences. For instance, given the premises that the pen on the desk, is matt-black pen on the desk then a knowledgeable agent ought to be able to infer that matt-black pen is on the desk.
- Thus as long as it makes sense to view agents to be 'something' drawing inferences about a domain, or performing reason - like operations, it makes sense to suppose they have a network of concepts which structures their knowledge.

(10) Knowledge and perception

- Immanuel Kant, a german philosopher, once said, 'sensation without conception is blind'. What he meant is that 'I do not know what I am seeing, if I have no concept to categorise my experience'. It is hard to imagine how we could identify entities if we did not have concepts. The reason is because object identification is an active process.
- Perception is not a passive system. It is a method for systematically gathering evidence about the environment. We can think of it as a guide offering answers to questions about the external world. Not direct answers but perceptual answers, that serve as an evidence for an agent certain perceptual 'conjectures'. One job of the perceptual system is to ask the right questions. Our eyes jump about an image looking for clues of identity; then search for confirmation of conjectures.

(11) Growth of knowledge

- A third feature of rational intelligence - learning - can be partially explained if we give to a system a set of disembodied concepts. Domain knowledge is much like a theory, it is a system of axioms relating basic concepts. Some axioms are definitional. Hence learning is movement along a trajectory of theories. It is a conceptual advance.
- This approach brings us closer to understanding the principles of learning, but a theory of intelligence which did not mention concepts would have to explain learning as a chance in capacities behaviourally or functionally classified. Disembodied concepts serve well enough.

1.9 SUB-AREAS OF AI

Various sub-areas of AI are as follows :

(1) Machine Learning.
(2) NLP (Natural Language Processing)
(3) Automation and Robotics.
(4) Machine Vision.
(5) Expert System (ES)
(6) Neural Computing
(7) Automatic Programming
(8) Genetic Algorithm
(9) Fuzzy Logic
(10) Intelligent Agents

1.9.1 Machine Learning

[Machine learning is one of the applications of AI where machines are not explicitly programmed to perform certain tanks, rather they learn and improve from experience automatically] .

It is a subfield of AI, which is defined **as the capability of a machine to imitate intelligent human behaviour**.

A.I. systems are used to perform complex tasks in a way that is similar to how humans solve problems. **Machine learning is one way to use Artificial Intelligence.**

Example of Machine Learning

(1) **Image recognition** is a well-known example of machine learning. It can identify an object as a digital image, based on the intensity of the pixels in black and white images or colour images.

(2) Machine learning is also **used** in 'internet search engines', e-mails filters to sort out spam, websites to make personalized recommendation, banking software to unusual transactions and lots of apps. on our phones such as voice recognition.

(3) Machine learning models learn, identify, pattern and make decisions with minimal intervention from humans. Ideally, machines increase accuracy and efficiency and remove or greatly reduce the possibility of human error.

(4) Machine learning is fascinating because programs learn from examples. From the collected data, a machine learning method can automatically analyse and learn the structure already resident in that data in order to provide a solution to the problem one is trying to solve.

1.9.2 Natural Language Processing (NLP)

- NLP is a branch of AI that enables machines to understand the human language. Its goal is to build systems that can make sense of text and automatically perform tasks like **translation, spell check or topic classification.**
- It is an intuitive behavior used to convey information and meaning with **semantic clues** such as words signs or images. The terms AI and NLP might conjure images of futuristic robots; there are already basic examples of NLP at work in our daily lives.
- The NLP techniques are widely used in Log Analysis and Log Mining. The different techniques such as tokenization, stemming parsing etc. are used to convert log messages into structural form.

1.9.3 Automation and Robotics

- Automation is the process of using physical machines, computer software and other technologies to perform tasks that are usually done by humans. Robotics is the process of designing creating and using robots to perform a certain task.
- If we are looking to assemble our products more quickly, a robot may be able to help you speed up your factory operations. If you are looking to make repetitive administrative tasks more efficient, software driven process automation would be more appropriate.

There are 3 types of automation

(i) Fixed automation
(ii) Programmable automation.
(iii) Flexible automation

Uses of Automation

- In order to freeing human workers to more engaging (and better paying) tasks, robots can reduce scrap and waste through improved accuracy, increased efficiency and operate around the clock.
- All of these benefits add up to much higher productivity in manufacturing operations.

1.9.4 Machine Vision

- Machine vision in robotics is the ability of a computer to see, it employs one or more **video cameras, analog-to-digital conversion (ADC)** and **digital signal processing (DSP)**. The resulting data goes to a computer or robot controller. Machine vision is similar in complexity to voice recognition.
- According to **Automated Imaging Association** (AIA) machine vision encompasses all industrial and non-industrial applications in which a combination of hardware and software provide operational guidance to devices in the execution of their functions based on the capture and processing of images.
- Machine value allows a robot to see what it is doing, in a sense. Without machine vision the robot would be blind-only capable of repeating the same exact tasks over and over until it is reprogrammed.
- Machine vision systems are embedded components that use data extorted from online images to automatically guide manufacturing and production operations, such as go/no testing and quality control processes. These systems can also play a role in **inspection operations** and **automated assembly verification**.

Types of Machine Vision

(1) D vision system,
(2) D vision systems,
(3) Line Scan or Area Scan
(4) D vision systems.

- A 'Vision System' is defined as a **rebuilt solution** that is ready to configure and deploy, containing the sensor, processor and software. Imaging systems are built up from many components including optics, illumination, cameras and software.
- Robotics is the intersection of science, engineering and technology that produces machines called **Robots**. It substitutes or replicate for human action. Pop culture has always been fascinated with robots.
- It is important to note that machine vision is in no way associated with image processing which is a process where the output is another image. The information that is captured by machine vision will be translated into a form of data to make sense of it such as the identity, position and orientation of the objects that are being captured by the machine vision system.

1.9.5 Expert System (ES)

- Expert System are a computerized program that attemtps to imitate the reasoning processes and knowledge of experts in solving the specific problems.
- Expert System are of great important and interest to organization because of their ability to enhance productivity and to augment workforces in many special areas where human experts are becoming increasingly difficult to find and retain.

1.9.6 Neural Computing

A neural network is a mathematical model of the way a brain functions. Neural networks are starting to have positive impact in many business disciplines.

1.9.7 Automatic Programming

- The goal of automatic programming is to create special program that act as intelligent tools to assist programmers and expedite each phase of the programming process.
- The ultimate aim of automatic programming is a computer system that could develop program itself, in response to and in accordance with the specifiations of a program developer.

1.9.8 Genetic Algorithm

- These are intelligent heuristic search methods that follows a process that simulates evolution in the computer.
- Genetic algorithm have been applied to many large-scale combinational mathematical programming problems such as large scale scheduling problem and even to producing police sketches of criminals.

1.9.9 Fuzzy Logic

- This extends the notions of logic beyond simple True/False to allow for partial or even continuous truths. Inaccurate knowledge and imprecise reasoning and important aspects of expertise in applying common sense to decision making situation.
- In fuzzy logic, degrees of set membership are important. In the traditional Boolean logic frame work, a car may be siad to skidding or not skidding when the break are applied.
- However, an expert driver can recognize the degree to which the car is skidding and can apply control according to variable amount of skidding. One of the commercial application of fuzzy logic was in producing superior antilock breaks.

1.9.10 Intelligent Agents

These are intelligent search methods that follows a process that simulates evolution in the computer. For example, in a specific problem, the solution is representing as chromosome, which generally contains a sequence of 0s and 1s, including the value of vector decisions variables.

For this string of chromosomes, the objective value can be compute.

1.10 AI PROBLEMS

Every new technology has its own share of problems. AI problems

AI problems

As an AI technology consumer and developer, we must know about both the merits and the challenges associated with the adoption of AI. Knowing these problems, helps the user to face the risks linked to the technology as well as take the full advantage of it.

It is very important how a developer addresses the AI problems in the real world. AI technologies must be accepted as a friend and not as a foe. We mention the top 10 potential artificial intelligence problems :

1. Lack of technical knowledge
2. The price factor
3. Data Acquisition and storage
4. Rare and expensive workforce
5. Issue of responsibility
6. Ethical challenges
7. Lack of computation speed
8. Legal challenges
9. AI Myths and expectation
10. Difficulty of assessing vendors'

(1) Lack of technical knowledge

- To implement AI applications in the enterprise, the organisation must have the knowledge of the current AI advancement and technologies and also its shortcomings.
- Enterprise requires a specialist to identify the roadblocks in the functioning process. Skilled human resources would help the teamwork with return on the tracking of adopting AI solutions.

(2) The price factor

- AI technology is a costly affair. Small and mid-sized organizations have to struggle a lot to adopt AI technologies.
- Even big firms like facebook, google, amazon have to allocate a separate budget for adopting and implementing AI technologies.

(3) Data Acquisition and storage

- One of the biggest AI problems is data acquisition and storage. Business AI systems depend on sensor data as its input.
- AI works best when it has a good amount of quality data available to it.

- The algorithm becomes strong and performs well as the relevant data grows.
- The AI system fails badly when enough quality data is not fed into it. With small input variations in data quality has profound results on outcomes and predications.
- Hence there is a real need to ensure greater stability and accuracy in Artificial Intelligence.

(4) Rare and expensive workforce

- Adoption and deployment of AI technologies require specialists like data scientists, data engineer and other Subject Matter Experts (SMEs).
- These experts are expensive and rare in the current marketplace. Small and medium -sized enterprises fall short of their tight budget to bring in the man-power according to the requirement of the project.

(5) Issue of responsibility

- The implementation of AI application comes with great responsibility.
- Any specific individual must bear the burden of any sort of hardware malfunctions.
- Earlier, it was relatively easy to determine whether an incident was the result of the actions of a user, developer or manufacturer.

(6) Ethical challenges

- One of the major AI problems are the ethics and morality.
- These problems are yet to be solved. The way how the developers are technically grooming AI applications to perfection, so that it can flawlessly imitate human conversations.
- That way it becomes increasingly difficult to spot a difference between a machine and a real customer service representation.
- Artificial intelligence algorithm predicts based on the training given to it. The algorithm will label things as per the assumption of data it is based on.
- Therefore, we need to make sure that the algorithms are fair, especially when it is used by private and corporate individuals.

(7) Lack of computation speed

- AI, machine-learning and deep learning solutions require a high degree of computation speeds. And it is offered only by high - end processors.
- Larger infrastructure requirements and pricing associated with these processors has become a hindrance in their general adoption of the AI technology.
- In this regard, cloud computing environment and multiple processors running in parallel offer a big alternative to face to these computational requirements.
- As the volume of data available for processing grows exponentially, the computation speed requirements will grow with it. Now it is required to develop next-generation computational infrastructure solutions.

(8) Legal challenges

- An AI data governance application can cause legal challenges for the company.
- This is again one of the biggest artificial intelligence problems that a developer faces in the real world. An incorrect algorithm will always make unfavourable predictions.
- Problems like data branch can be a consequence of weak and poor data governance. To an algorithm, a user's 'personal identifiable information' (PII) acts as a feed stock which may slip into the hands of hackers.
- And the organisation may fall into traps of legal challenges.

(9) AI Myths and expectation

- There is a lot of discrepancy between the actual potential of the AI system and the expectations of this generation.
- Media says, Artificial intelligence, with its cognitive capabilities, will replace human's jobs.
- AI is just a tool that can operate only with the help of human brains. AI can replace human roles like automation of routine or common work optimizations of every industrial work, data-driven predictions etc.
- However, in most of the occasions, AI cannot substitute the caliber of the human brain. Not everything we hear about AI is true. AI is often over-hyped.

(10) Difficulty of assessing vendors

- In any emerging field, a technological procurement is quite challenging as AI is particularly vulnerable. Businesses face a lot of problems to know how exactly they can use AI effectively.
- The key lies in minimising the AI problems and maximising the benefits through the creation of an extensive technology adoption roadmap that understands the main capabilities of artificial intelligence.

1.10.1 Programming Without and With AI

UQ. Differentiate Programming Without and With AI **(MU - Q. 1(d), Dec. May 18, 4 Marks)**

Parameters	Programming Without AI	Programming With AI
(1) Computer program	A computer program without AI can answer the Specific questions it is meant to solve.	A computer program with AI can answer the Generic questions it is meant to solve.
(2)Modifications	Modification in the program leads to change in its structure.	AI programs can absorb new modifications by putting highly independent pieces of information together. Hence we can modify even without affecting its structure.
(3) Complexity	Modification is not quick and easy. It may lead to affecting the program adversely.	Quick and Easy program modification.

1.11 CURRENT TRENDS IN AI

While the COVID - 19 pandemic impacted many aspects of how we do business, it did not diminish the impact of Artificial Intelligence (AI) on our everyday lives. AI remains a key trend when it comes to technology and innovations that will fundamentally change how we live, work, and play in the near future.

AI is the force behind many modern technological comforts that are now part of our day -to - day lives. With continuous research, technology has made massive developments in major fields such as health-care, retail, automotive, manufacturing and finance. AI is one essential component that transforms the digital age with high precision and accuracy. So, here there is an overview of what we can expect in the years to come.

1. Robotic Process Automation (RPA)
2. Conversational AI
3. The role of AI in healthcare
4. Increase in demand for ethical AI
5. AI for cyber security and knowledge breach
6. The Intersection of the Internet of Things with AI (AIOT)
7. Natural Language Processing (NLP)
8. Reinforcement Learning
9. Quantum AI
10. AI-Powered Business and Forecasting and Analysis
11. Edge computing
12. Rise of a hybrid work force

(1) Robotic Process Automation (RPA)

- To streamline business processes and reduce costs, they are turning to an evolving technology practice called as robotic process automation (RPA)
- RPA is aimed at the automation of business processes, governed by business logic, and organised inputs.
- RPA solution range from producing an automated email response to deploying thousands of bots. Each is programmed in an ERP system to automate rule-based tasks.

(2) Conversational AI

- Conversational AI increases the customer experience's reach, responsiveness and personalisation.
- To better understand what the human says and needs, AI uses natural language processing (NLD) and machine learning to provide a more natural, near human - level interaction.

(3) The role of AI in healthcare

- Big data has been extensively used to identify COVID patients and critical hot points.
- AI is already helping the health-care sector to a great degree with high accuracy besides, researchers have developed thermal cameras and mobile applications to collect data for healthcare organisations.

- By leveraging data analysis and predicting various outcomes, AI can support healthcare facilities in several unique ways.
- AI instruments offer insights into human health and also recommend preventive steps to avoid the spread of diseases.
- AI solutions also help doctors remotely track the health of their patients, thereby advancing teleconsultation and remote care.

(4) Increase in demand for ethical AI

- This demand is at the top of the list of emerging developments in technology.
- Looking at how trends are rapidly changing, values-based customers and workers expect businesses to implement AI responsibly.
- Companies will actively choose to do business with partners committed to data ethics in the next few years.

(5) AI for cyber security and knowledge breach

- In the coming years, knowledge will grow and will be accessible, and digital data will be at greater risk of being compromised and exposed to hacking . AI will help deter cybercrimes in the future with improved cyber security measures.
- Fake digital activity that match criminal trends will be detected by the AI-enabled framework.

(6) The Intersection of the Internet of Things with AI (AIOT)

- There is hardly any boundary between AI and IOT. Although both technologies have individual characteristics, when used together, better and more unique possibilities open up.
- The ability of AI to gain insights from data quickly makes IOT solutions more intelligent.

(7) Natural Language Processing (NLP)

- NLP is one of the widely used applications of AI. N LP is used in Amazon, Alexa and Google Home.
- The need for writing or communicating with a screen has been eliminated by NLP as now humans can communicate with robots that understand their language.
- NLP is used for sentiment analysis, machine translation, process description, auto-video caption generation and chatbots is expected to increase.

(8) Reinforcement Learning

- Reinforced Learning (RL) is a specific application of deep learning. Its work is based on its experience to enhance the efficiency and effectiveness of data.
- Some cases of use of RL are robotics in planning business strategies, optimising advertisement content, automating industries, controlling aircraft, and making motion control robots.

(9) Quantum AI

- To measure the Qubits for use in supercomputers, advanced companies will begin using quantum supremacy. Because of quantum bits, quantum computers solve problems at a quicker pace than classic computers do.
- Also they assist in the interpretation of data and then forecast several unique trends.
- Quantum computers will help multiple organisations identify inaccessible issues and also predict meaningful solutions. Future computers will also be used in fields like healthcare, finance and chemistry.

(10) AI-Powered Business and Forecasting and Analysis

- AI solutions help in redefining business processing with real-time alerts.
- Content-intelligent technologies, along with AI-supportive practices, will assist digital workers to develop outstanding abilities.
- Such skills can help them cope with the automation of natural language, judgment, context formation, reasoning and data-related insights.

(11) Edge computing

- Edge computing provides gadgets with servers and data storage to access their devices and allows them to put data into them. It is defined as data processing in real-time and is more powerful than 'cloud computing services'.

- There is another instance of edge computing that uses nodes. It is a mini-server located in the vicinity of a local telecommunications provider.
- Nodes help to build a bridge between the local service provider. It costs less, saves time and provides customers with fast service.

(12) Rise of a hybrid work force

- Post the COVID-19 pandemic, companies will change on to RPA bandwagon, which means that cognitive AI and RPA will be widely applied to cope with high volume, repetitive activities.
- If usages grow, the office will move to a hybrid workforce environment.
- The human workforce will work with various digital assistants. The emergence of a hybrid workforce will imply more collaborative experiences with AI.

1.12 APPLICATION AREAS OF ARTIFICIAL INTELLIGENCE

UQ. What are applications of AI?

(MU - Q. 1(a), May 17, 5 Marks)

(1) Logical artificial intelligence : What a program knows about the world in general the facts of the specific situation in which it must act, and its goals are all represented by sentences of some **mathematical logical language**. The program decides what to do by inferring that certain actions are appropriate for achieving its goals.

(2) Search : Artificial intelligence programs often examine large numbers of possibilities, **e.g.** moves in a chess game or inferences by a theorem proving program. Discoveries are continually made about how to do this more efficiently in various domains.

(3) Pattern recognition : When a program makes observations of some kind, it is often programmed to compare what it sees with a pattern. For example, a vision program may try to match a pattern of eyes and a nose in a scene in order to find a face. More complex patterns, e.g. in a natural language text, in a chess position, or in the history of some event are also studied.

(4) Representation : Facts about the world have to be represented in some way. Usually languages of mathematical logic are used.

(5) Inference : From some facts, others can be inferred. **Mathematical logical deduction** is adequate for some purposes, but new methods of non-monotonic inference have been added to logic since the 1970s. The simplest kind of **non- monotonic reasoning** is default reasoning in which a conclusion is to be inferred by default, but the conclusion can be withdrawn if there is evidence to the contrary. **For example**, when we hear of a bird, we can infer that it can fly, but this conclusion can be reversed when we hear that it is a penguin. It is the possibility that a conclusion may have to be withdrawn that constitutes the **non-monotonic character** of the reasoning. Ordinary logical reasoning is monotonic in that the set of conclusions that can be drawn from a set of premises is a monotonic increasing function of the premises.

(6) Common sense knowledge and reasoning : This is the area in which artificial intelligence is farthest from human-level, in spite of the fact that it has been an active research area since the 1950s. While there has been considerable progress, e.g. in developing systems of non-monotonic reasoning and theories of action, yet more new ideas are needed.

(7) Learning from experience : Programs learn from experience. The approaches to artificial intelligence based on connectionism and neural nets specialize in that. There is also learning of laws expressed in logic. Programs can only learn what facts or behaviours their formalisms can represent, and unfortunately learning systems are almost all based on very limited abilities to represent information.

(8) Planning : Planning programs start with general facts about the world (especially facts about the effects of actions), facts about the particular situation and a statement of a goal. From these, they generate a strategy for achieving the goal. In the most common cases, the strategy is just a sequence of actions.

(9) Epistemology : This is a study of the kinds of knowledge that are required for solving problems in the world.

(10) Ontology : Ontology is the study of the kinds of things that exist. In artificial intelligence, the programs and sentences deal with various kinds of objects, and we study what these kinds are and what their basic properties are. Emphasis on ontology begins in the 1990's.

(11) Heuristics : A heuristic is a way of trying to discover something or an idea embedded in a program. Heuristic functions are used in some approaches to search to measure how far a node in a search tree seems to be from a goal. Heuristic predicates that compare two nodes in a **search tree** to see if one is better than the other, i.e. constitutes an advance toward the goal, and may be more useful.

(12) Genetic Programming : Genetic programming is a technique for getting programs to solve a task by making random LISP programs and selecting fittest in millions of generations.

Chapter Ends...

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