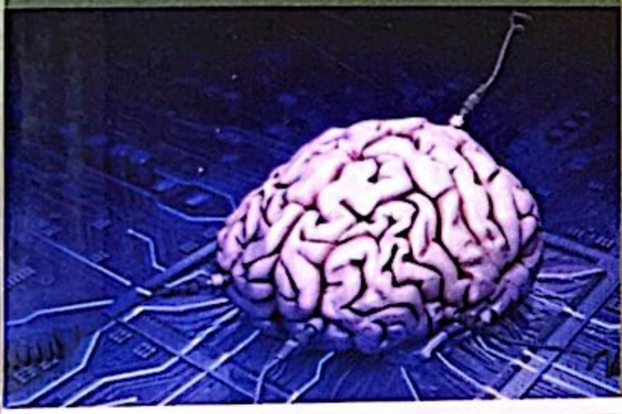
Revised Edition

ARTIFICIA INTELLIGE

A PRACTICAL A



ARTIFICIAL INTELLIGENCE
A PRACTICAL APPROACH

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Writing a good book which gives practical exposure also is not an easy job. It requires sincere efforts, hard work and blessings of omnipresent God and others who all motivated me to write this book.

I gratefully acknowledge the support given by the Management Team and Editorial Staff of S. Chand & Company Ltd., New Delhi for publishing the book on time and with a nice format.

I am also thankful to my wife Mrs. Shakti Chopra, my twin babies — Arjeesh (son) and Arshitha (daughter) for their constant support and patience and also the encouragement given by my parents, Dr. J.R. Chopra (Ex. Prof. of Physics) and Mrs. Sushma Chopra (Ex. Principal).

Er. RAJIV CHOPRA

PREFACE TO THE SECOND EDITION

Many books on AI are available in market but they tend to be very formal and dry. My attempt is to make AI very simple so that a student thinks as if a teacher is sitting behind him and guiding him. AI has two main goals — building intelligent machines and understanding the nature of intelligence. Expert systems are computer-based systems that use knowledge often acquired from human experts to solve problems reading such expertise as in medical diagnosis, legal advising, tax planning, image interpretation and engineering design. AI and ES are linked via Knowledge Engineering (KE). KE is concerned with reducing a large body of knowledge to a set of facts and rules of a knowledge base and the inference procedures required for utilizing that knowledge for problem solving. KE is concerned with the task of building expert systems using appropriate tools.

This text is bolstered with many solved and unsolved problems, CASE STUDIES, experiments of AI in LISP and PROLOG programming of all Indian Universities. Every effort has been made to alleviate the treatment of the book for easy flow of understanding of students as well professors alike.

Any suggestions to enhance the quality of the book will be highly acknowledged and welcomed.

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Er. RAJIV CHOPRA

GGSIPU B.TECH (CSE/IT) (SEM VIII)

Paper: Artificial Intelligence 2010-11

Code No.: **ETCS 402** | **L T C**
Paper: **Artificial Intelligence** | **3 1 4**

Instructions to Paper Setters:

1. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
2. Apart from question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be of 12.5 marks.

UNIT-1

Scope of AI: Games, theorem proving, natural language processing, vision and speech processing, robotics, expert systems, AI techniques-search knowledge, abstraction.

Problem Solving (Blind): State space search: production systems, search space control; depth-first, breadth-first search.

Heuristic Based Search: Heuristic search, Hill climbing, best-first search, branch and bound, problem reduction, constraint satisfaction end, means-end analysis.

[No. of Hrs: 12]

UNIT-II

Game Playing: Game tree, minimax aLgorithm, alpha beta cutoff, modified minimax algorithm, horizon effect, futility cut-off.

Knowledge Representation: Predicate Logic: Unification, modus Ponens, modus tolens, resolution in predicate logic, conflict resolution, forward chaining, backward chaining, declarative and procedural representation, rule-based systems.

Structured knowledge representation: semantic nets: slots, exceptions and default frames, conceptual dependency, scripts.

[No. of Hrs.: 12]

UNIT-III

Handling Uncertainty: Non-monotonic reasoning, probabilistic reasoning, use of certainty factors, fuzzy logic.

Natural language processing: introduction, syntactic processing, semantic processing, pragmatic Processing.

[No. of Hrs.: 10]

UNIT-IV

Learning: Concept of learning, learning automation, genetic algorithm, learning by inductions, neural nets.

Expert systems, need and justification for expert systems, knowledge acquisition, case studies: MYCIN, RI.

[No. of Hrs.: 10]

GGSIPU B.TECH (CSE/IT) (SEM VIII)

Academic Plan for VIII Semester (For Year 2011-12)

Subject: Artificial Intelligence
Teaching weeks in semester: 14 weeks

Code No.: ETCS 402 Total
Total number of lecturers: 40
Total number of tutorials: 16

S. No.	Topics to be covered	Total no. of lectures	Total no. of tutorials
	First Term		
	Scope of AI: Games, theorem proving, natural language processing, vision and speech processing, robotics, expert systems, AI techniques-search knowledge, abstraction.	3	3
	Problem Solving (Blind): State space search; production systems, search space control; depth-first breadth-first search.	1	
	Heuristic Based Search: Heuristic search, Hill climbing, best-first search, branch and bound, problem reduction. constraint satisfaction end, means-end analysis.		
	Knowledge representation: predicate logic: unification, modus ponens, modus tolens, resolution in predicate logic, conflict resolution, forward chaining, backward chaining, declarative and procedural representation, rule-based systems.	4 2 6	2 2
	Structural knowledge representation: semantic nets: slots, exceptions and default frames, conceptual dependency, scripts.	2	1
	Second Term:		
	Game Playing: Game Tree, minimax algorithm, alpha beta cutoff, modified minimax algorithm, horizon effect, futility cut-off.	4	2
	Handling Uncertainty: Non-Monotonic reasoning, probabilistic reasoning, use of certainty factors, fuzzy logic.	4	
	Expert System: Need and justification for expert systems, knowledge acquisition, case studies: MYCIN, RI.	5	2
	Learning: Concept of learning automation, genetic algorithm, learning by inductions, neural nets.	5	2
	Third Term		
	Natural language processing: introduction, syntactic processing, semantic processing, pragmatic processing.	4	2

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INTRODUCTION TO AI

1.0 INTRODUCTION

We need to develop some paradigms or algorithms that cause our machines to perform tasks that otherwise require cognition or perception when performed by humans. Any artificially intelligent system must possess three essential components:–

1. A means for representation of diverse kinds of knowledge

Knowledge may be generic and domain specific, implicit and at different levels of abstraction. The representation mechanism that we opt must be able to handle this knowledge in any form. **Please note that a representational structure enforces certain limitations on the nature of inferences that can be drawn from the embedded knowledge.**

2. A framework for reasoning

We need to have some control mechanisms to constrain the search through a Knowledge Base (KB) and the means of arriving at conclusions.

3. A mechanism for learning

An artificial intelligent system must have a method of learning new data, storing it in the existing structures internally with minimal or no disturbances to them.

Classical AI or Good Old Fashioned AI is **symbolic** and **top-down** in its approach.

What is AI exactly?

According to Patterson, "AI is a branch of computer science that deals with the study and the creation of computer systems that exhibit some form of intelligence." By **'intelligence'** we mean

(*a*) Systems that learn new concepts and tasks;

(*b*) Systems that can reason and draw useful conclusions about the world around us;

(*c*) Systems that can understand a natural language or perceive and comprehend a visual scene; and

(*d*) Systems that perform other types of feats that require human types of intelligence.

Many other definitions of AI have been given:

1. **General definition:** "An understanding of AI requires an understanding of related terms such as intelligence, knowledge, reasoning, thought, cognition, learning and solving problems."
2. **By Advert:** "AI is the part of computer science concerned with designing intelligent computer systems *i.e.* systems that exhibit characteristics that we associate with intelligence in human behavior."
3. **By heuristic (i.e., Rule of Thumb):** "AI is the branch of computer science that deals with the ways of representing knowledge using symbols rather than numbers and with the rules of thumb for processing information."

4. **Modern definition: "AI is defined as the branch of computer science dealing with symbolic and non-algorithmic method of problem solving."**

> **NOTE:** AI works with "*pattern-matching*" methods which attempt to describe object, events and process in terms of their qualitative nature and logical and combinational relationship.

Please understand that "**intelligence**" is a catchy word here. **Intelligence** means an integrated sum of all knowledge and facts, acquired through study and experience. **Also note that the food for this intelligence is knowledge.**

AI task domain

Basically, AI covers three types of tasks:

(*a*) Mundane tasks

(*b*) Formal tasks

(*c*) Expert tasks

Let us understand these tasks now.

I. Mundane tasks

AI has some mundane tasks also like,

(*a*) Perception of vision and speech.

(*b*) Natural language understanding.

(*c*) Common sense reasoning.

(*d*) Robotics.

II. Formal tasks

AI formal tasks include:

(*a*) Game playing, e.g., chess, 8-queens problems, water-jug problem etc.

(*b*) Mathematics — geometry, calculus, etc.

III. Expert tasks

It includes:

(*a*) Engineering field.

(*b*) Scientific analysis.

(*c*) Medical and financial analysis.

What AI is NOT?

1. **AI is not the study and creation of conventional computer systems.**

All programs exhibit some degree of intelligence and an AI program must go beyond this degree of intelligence also. This is not the case. Remember that human beings are more intelligent than our intelligent systems also as we only have created them.

2. **AI is not the study of mind, nor of body, nor of languages, as found in fields of psychology physiology, cognitive science or linguistics.**

Although there is some overlap between these fields and AI, yet the goal of AI is to develop a computer system that is capable of performing intelligent tasks effectively and efficiently.

So, what AI will include? It includes areas like:

(*a*) Robotics

(*b*) Memory organization

(*c*) Knowledge representation

(d) Storage and recall
(e) Learning models
(f) Inference techniques
(g) Common sense reasoning
(h) Decision making.
(i) Pattern recognition
(j) Searching
(k) Speech recognition
(l) Speech synthesis.

History of AI

Let us see the history of AI in 1950s, 1960s, 1970s, 1980s and 1990s in a tabular form now.

Year	Developments made
1950s	o Birth of AI o First Neural Net Simulator (Minsky) o GPS—General Purpose Problem Solver (Simon) o GTP—Geometry Theorem Prover—(Gelertber), input diagrams, backward reasoning. o SAINT—Symbolic integration
1960s	o ANALOGY—could solve IQ test puzzle o STUDENT—could solve algebraic word problems o SHRDLU—could manipulate blocks using robotic arm o STRIPS—a problem solver planner o Minsky and Papert—demonstrated the limitations of neural nets
1970s	o Conceptual Dependency theory (Shank) o Frames (Minsky) o Machine Learning: ID3 (Quinlan), AM (Lenat) o Expert system got success o DENDRAL by Feigenbaum— to identify molecular structure. o MYCIN by Shortliffe and Buchanan – to diagnose infectious blood diseases
1980s	o Cheaper computing, so AI Software a feasible success, neural nets revisited o XCON (by McSermott)—saved $ 40m per year o Neural computing—back propagation (Werbos), associative memory (Hopfield), logic programming developed and used
1990s	o Embedded intelligent systems, agents o Hybrid approaches: logic + neural nets + genetic algorithms + fuzzy logic o CYC (by Lenat)—a far-reaching project to capture common sense reasoning o Society of Mind (Minsky)—Intelligence is a product of complex interactions of simple agents o Deep Blue (formerly Deep Thought)—defeated Kasparov in speed chess in 1997

Let us see the entire history now, from 1941 to 1991.

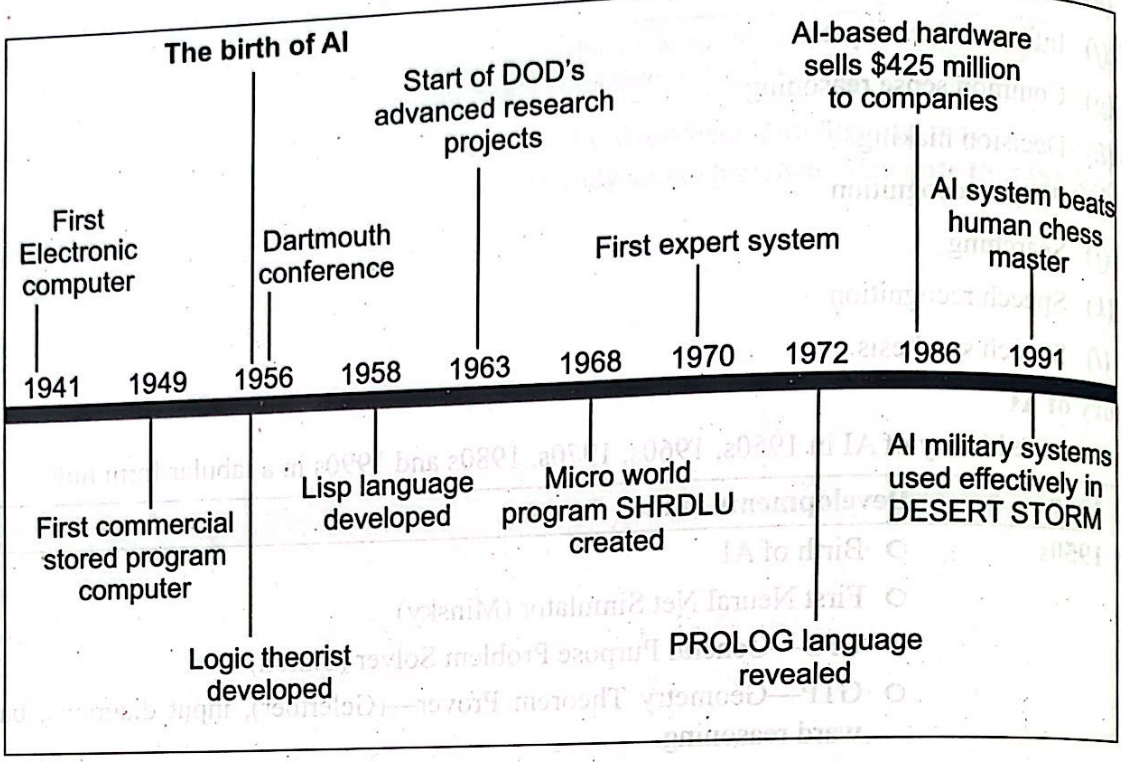

Fig. 1.1 History of AI.

1.1 SCOPE OF AI

AI has a very wide scope. Some of its applications are discussed below:

1.1.1 Games

According to Newell and Simon (1976), **the essential basis for human problem solving** is to **systematically explore a space of problem states, i.e., successive and alternative stages in the problem solving.** For example, the different board configurations in a chess game or intermediate steps in a reasoning process. This space is called as **state space**. This space of alternative solutions is then searched to find a final answer.

Please understand that games can generate extremely large search spaces. So, we need powerful techniques to search for our solution in this space. **These techniques are called** as **heuristics. Also note that intelligence resides in heuristics only.** So, AI helps here.

1.1.2 Theorem Proving

It is a formal system wherein logic lends itself to automation. A large variety of problems can be solved by using logical axioms and treating problem instances as theorems to be proved. Theorem proving has devised powerful solution heuristics and reduced the complexity of the search space. **For example,** design and verification of logic circuits, control of complex systems etc., will respond to such an approach.

Many modern theorem provers function as **'intelligent assistants'**. By this we mean that it allows humans to do the task of decomposition of large problems into subproblems and devising heuristics for searching the space of possible proofs. On the other hand, the **theorem prover** then performs the simpler but still demanding task of proving lemmas, verifying smaller guesses and completing the formal aspects of a proof outlined by the humans.

1.1.3 Natural Language Processing (NLP)

It is a subfield of AI which deals with the methods of communicating with a computer in one's own natural language. This will fill the gap between the humans and the machines. So, now one need not be computer literate to communicate with it.

1.1.4 Vision and Speech Processing

Computer vision is a computation intensive process. It involves multiple transformations. This relies more on classical AI methods of symbolic processing.

Speech understanding requires recognition of basic speech patterns. These patterns are matched against lexicon patterns for recognition. Developing systems that understand speech has been a continuing goal of AI researchers.

1.1.5 Robotics

According to the Robot Institute of America (RIA) — **"A robot is a reprogrammable, multifunctional, manipular that is designed to move materials, parts, tools or specialized devices through various programmed motions for the performance of a variety of tasks."**

Today, we need intelligent Robots to make them smaller devices. So, intelligence needs to be embedded into it. So, now vision is very essential. These intelligent robots as well as AI promise us to solve our complex problems easily.

1.1.6 Expert Systems (ES)

They are knowledge intensive programs that solve problems in a domain that needs a good technical expertise. As per the definition given by British Computer Society's Committee of the Specialist Group on Expert Systems—

"The embodiment within a computer of a knowledge-based component from an expert skill in such a form that the machine can offer intelligent advice or take an intelligent decision about a processing function. A desirable additional characteristic which many would regard fundamental, is the capability of the system on demand to justify its own line of reasoning in a manner directly intelligible to the inquirer. The style adopted to attain these characteristics is rule-based programming."

So, we find from this definition that an AI specialist or a knowledge engineer or expert system designers are responsible for implementing knowledge in a program, both effectively and intelligently.

For example,

1. **DENDRAL** — developed at Stanford University in late 1960s. It was designed to infer the structure of organic molecules from their chemical formulas and mass spectrographic information about the chemical bonds present in the molecules. As these organic molecules tend to be very large, so the number of possible structures for these molecules tend to be huge. DENDRAL addresses this problem of a large search space by applying the heuristics knowledge of expert chemists to the structure elucidation problem.

   DENDRAL used domain specific knowledge for this.
2. **MYCIN** — It uses the expert medical knowledge to diagnose and prescribe treatment for spinal meningitis and bacterial infections of the blood. It was developed at Stanford in mid-1970s. It provides clear and logical explanations of its reasoning. It uses a control structure appropriate to the specific problem domain.
3. **PROSPECTOR** — A program for determining the probable location and the type of ore deposits based on geological information about a site.

   Please note that most expert systems have been written for relatively specialized expert level domains.

1.2 AI TECHNIQUES

I. Search Knowledge

Knowledge can be defined as the body of facts and principles accumulated by humankind or **the act, fact or state of knowing. For example, in biological organisms, knowledge is stored** as complex structures of interconnected neurons. The structures correspond to symbolic representations of the knowledge possessed by the organism, the facts, rules and so on. **Please note that an average human brain weighs about 3.3 pounds and contains an estimated number of 10^{12} neurons. Also note that these neurons and their interconnection capabilities provide about 10^{14} bits of potential storage capacity.** On the other hand, in computers knowledge is stored as symbolic structures but in form of collections of magnetic spots and voltage states.

Knowledge is of three types as shown below:

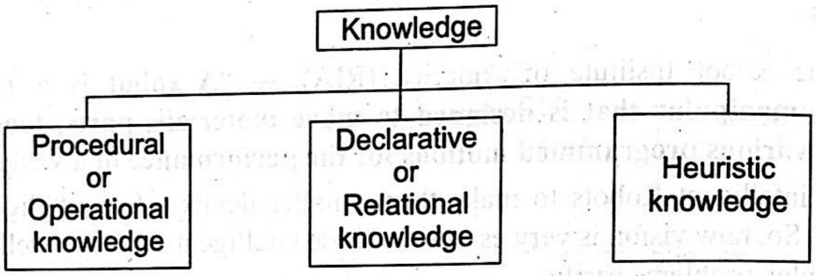

Fig. 1.2 Types of knowledge

Let us define these types now.

1. Procedural or Operational Knowledge

It is defined as a compiled knowledge related to the performance of some task. For example, steps to solve a quadratic equation are expressed as a procedural knowledge.

2. Declarative or Relational Knowledge

It is a passive knowledge expressed as statements of facts about the world. For example, personnel data in a database. Such data are explicit pieces of independent knowledge.

3. Heuristic Knowledge

Heuristics means using some rules of thumb or tricks or some strategies to simplify the solution to problems. We acquire this after much experience.

Some terminologies related to knowledge

We define certain terms that will be used again and again here. They are as follows:

1. **Knowledge and data:** A doctor has both **knowledge** as well as **data.** Here, **data** is the patient's record whereas **knowledge** is what he has learned in his medical college. This was explained by Feigenbaum and McCorduck.
2. **Belief:** It is defined as essentially any meaningful and coherent expression that can be represented. It may be true or false.
3. **Hypothesis:** It is defined as a justified belief that is not known to be true. It is backed up with some supporting evidences but it may still be false.
4. **Knowledge:** It is a true justified belief.
5. **Meta knowledge:** It is the knowledge about the knowledge.
6. **Epistemology:** It is the study of the nature of knowledge.

AI technique is a method that exploits knowledge that should be represented in such a way that:

1. It captures generalizations.
2. It can be understood by people who must provide it.

3. It can be easily modified to correct errors and to incorporate changes.
4. It can be used many situations even if it is not totally accurate or complete.
5. It can be used to help overcome its own sheer bulk by helping to narrow the range of possibilities that must usually be considered.

Please note that it is possible to solve AI problems without using AI techniques but the solutions would be inefficient. Also it is possible to apply AI techniques to the solution of non-AI problems and this will be a good thing for those problems that possess same characteristics as AI problems have.

Those systems that depend on a rich base of knowledge to perform difficult tasks are known as knowledge-based systems.

A knowledge-based system (KBS) consists of three main components as shown in Fig. 1.3.

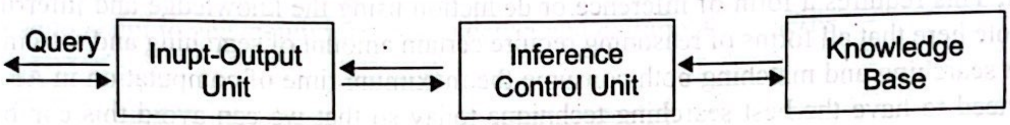

Fig. 1.3 Components of a KBS

Explanation: KBSs get their power from the expert knowledge that has been coded into facts, rules, heuristics and procedures. The knowledge is stored in a knowledge base only. Since it is stored separately (from I/O unit and Inference CU) so we can easily add new knowledge to this knowledge base or refine existing knowledge without recompiling the control and inferencing programs. So, now the construction as well as the maintenance of KBS becomes very simple.

Knowledge-base is different from database. **Let us tabulate the differences between them now.**

Data Base (DB)	**Knowledge Base (KB)**
1. It is defined as a collection of data representing facts.	1. It has information at a higher level of abstraction.
2. It is larger than a KB.	2. It is smaller than a DB.
3. Changes are fast.	3. Changes are gradual.
4. All information needs to be stated explicitly.	4. It has the power of inferencing.
5. It is mainttained for operational purposes.	5. It is used for data analysis and planning.
6. Knowledge is represented by relational, network or hierarchical model.	6. Knowledge is represented by logic or rules.

Knowledge may be represented at various levels as shown in Fig. 1.4.

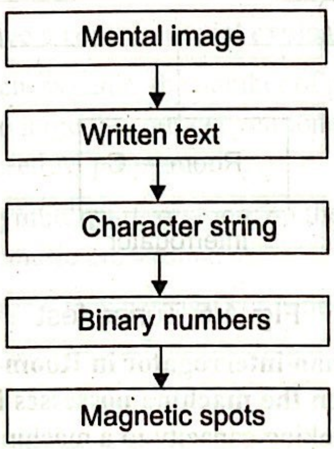

Fig. 1.4 Levels of knowledge representation

Please note, however, that any choice of representation will depend on the type of problem to be solved and the inference methods available.

Not only this, knowledge organization in memory is also very vital. The KBS discussed in Fig. 1.3 may require several (tens of thousands) of facts and rules to perform their intended tasks. So, now it is mandatory to easily search, locate and retrieve appropriate facts and rules from this KB. We use indexings to speed up searches — we can form groups of knowledge of similar type and then make a pointer to point to this group. So, now instead of searching for an entire KB, only a small portion of it may be accessed.

We need to manipulate this knowledge also. Usually, the user gives some input and thus initiates a search for a **goal** or **decision. Please understand that this requires that known facts in the KB be located, compared (matched) and altered somehow. Also note that this process may set up some sub-goals which requires some more inputs and so on until a final solution is found.** This requires a form of inference or deduction using the knowledge and inferring rules. Please note here that all forms of reasoning require certain amount of searching and matching. Also note that searching and matching both consume the maximum time of computation in AI systems. So, we need to have the best searching technique today so that we can avoid this combinatorial explosion problem during searching.

Now, the question is **how to acquire knowledge?** Knowledge may be acquired from sources like textbooks, references, reports, technical research papers and so on and to be **useful**, it should be accurate, complete, inconsistent and so on. Our KBS depends on a high quality knowledge for their success.

1.3 ALAN TURING MACHINE

In 1950, Alan Turing published an article in the "Mind Magazine" which triggered a controversial topic — **"Can machines think?"** So, the **Turing test is —"A computer is programmed well enough to have a conversation with an interrogator and passes the test if the interrogator cannot discern if there is a computer or human at the other end."**

It means that in this imitation game there are three actors —

(*a*) a male,

(*b*) a female, and

(*c*) an interrogator.

That is,

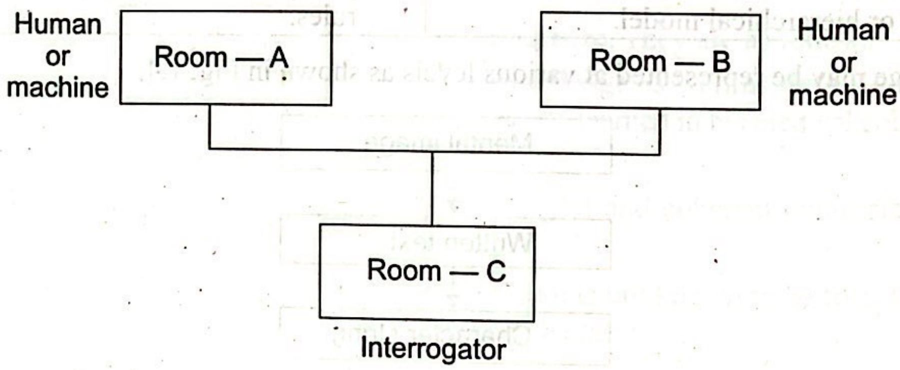

Fig. 1.5 Turing test

Turing proposed that if a human interrogator in Room-C (Fig. 1.5) is not able to identify who is in Room-A or Room-B, then the machine possesses intelligence. Turing considered this as a sufficient test for attributing thinking capacity to a machine. This test is not that easy as given here because we know that humans are far more superior in common sense and reasoning. But, even today this Turing test is the ultimate test that a machine must pass in order to be called as intelligent.

So, the full Turing test is — to consider a machine to be intelligent we need to test that —

"Can machines think?" ↔ "Can machines behave intelligently?"

So, for this imitation game above, the Turing test needs an operational definition of intelligence.

For this the computer needs to possess the following —

(a) Natural Language Processing (NLP)

It is required to communicate with Room-A or Room-B.

(b) Knowledge Representation

It is required to store and retrieve information provided before or during interrogation.

(c) Automated Reasoning

It is used to access stored information to answer queries and to draw new conclusions.

(d) Machine Learning

It is needed to adapt to new conditions and to detect and extrapolate patterns.

(e) Vision

It is required for total Turing test – to recognize interrogator's actions above.

(f) Motor Control

It is to act upon objects as requested.

(g) Senses

For total Turing test, these are needed like smell, touch, etc.

Please understand that for a program to pass this Turing test, it needs to pass and exhibit these capabilities.

Limitations of Turing Test

Turing test has certain drawbacks which are given below—

1. Say, a machine has passed the Turing test. Now, the question is as to what level of proficiency it has achieved? We can say that it is the level of programmer only, that is, its proficiency. In fact, a machine demonstrates the intelligence of human brains only.
2. What happens if a machine passes this Turing test, is intelligent, manipulates all formal symbols but lacks understanding.
3. Turing test is not reproducible, constructive and amenable to mathematical analysis.
4. It does not consider about the physical interaction with the interrogator and the environment.

1.4 CHARACTERISTICS OF AI PROBLEMS

1. Almost all AI problems have a **combinatorial explosion** of solutions.

   For example, in case of a chess game, the number of possible positions has been estimated to about 35^{100}, which is too large. So, our conventional computers cannot handle this huge solution space. Thus, we need AI programs.
2. AI programs manipulate symbolic information, on the other hand conventional computers (or programs) deal with numeric processing.
3. An AI program needs a large KB, whereas a conventional program needs a large DB.
4. An AI program has an ability to learn. Conventional systems have not achieved that level till now.
5. An AI program needs an imprecise knowledge whereas a conventional program needs a precise knowledge.

Let us tabulate the differences between the two now.

AI Program	Conventional Program
1. It manipulates symbolic information.	1. It manipulates numeric information.
2. It uses heuristic search method.	2. It uses algorithmic search method.
3. It seeks for satisfactory answers.	3. It seeks for optimal answers.
4. It involves large KB.	4. It involves large DB.
5. It involves frequent modifications.	5. It involves rare modifications.

1.5 INTELLIGENT AGENTS

These are software programs which work in the background to carry out specific, repetitive, predictable task for an individual user. Alan Turing suggested that a system or agent can be said to be **intelligent** when the agent's performance cannot be distinguished from that of a human performing the same task. Thus, we define now. **An intelligent agent is a software entity which senses its environment and then carries out some set of operations on behalf of a user with some amount of autonomy and to do so, it employs some knowledge or representation of the end-user's goal. Please note that an agent is different from a program.** An **agent** need not be a program at all. It may be a robot or a college professor. Also note that Software agents are by definition programs but a program must measure up to several marks to be an agent.

For example, humans, animals, autonomous mobile robots or softbots calculators are **real-world agents. Software agents** live in system's O.S.

Please understand that systems are agents or not with respect to some environment. AI is about the design and implementation of intelligent agents. The concept is shown below in Fig. 1.5.

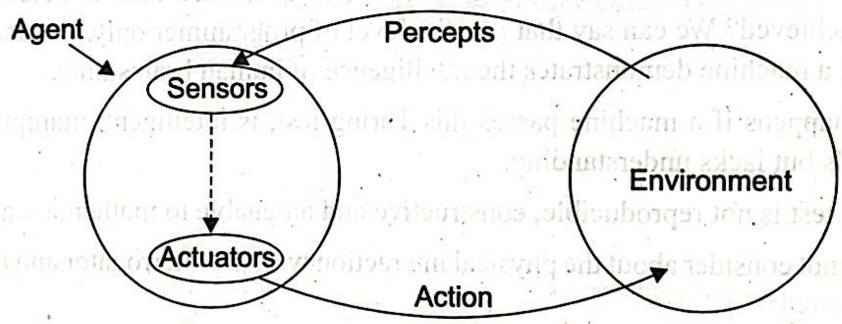

Fig. 1.6 Role of an agent

As shown in Fig. 1.6, an **agent** perceives its environment through sensors. It then acts upon that environment through **actuators.**

For examples—

1. A human agent has eyes, ears, nose etc. as sensors while hands, legs, mouth are actuators.
2. Software agent receives keystrokes, files, packets are sensory inputs and acts on the environment by displaying on the screen, writing files and sending packets over a network.

Characteristics of Agents

Agents have some features which are listed below:

1. They are **autonomous,** i.e., can work on their own.
2. They are **persistent** over a prolonged time period.
3. They are **adaptive,** i.e., adjust to changes.

4. They are **mobile, i.e., can be transported over networks.**
5. They have ability to **learn.**

Applications of Intelligent Agents (IA)

There are some major applications of IA and are given below—

1. IAs are used to access and navigate information using different search engines.
2. IAs help in decision-making by the knowledge workers.
3. IA like **voice-activated interface agent** reduces the user's task of explicitly commanding the computer.
4. IAs perform the time-consuming and combersome tasks of searching databases, doing retrievals and filtering of information and sending the result-sets back to the user, in distributed environments.
5. IAs can be used to assist managers to do their job. Some management-oriented tasks that an agent can do are— advising, alter, browse, distribute, enlist, explain, filter, guide, match, monitor, navigate, negotiate, organize, query, report, remind, retrieve, schedule, search, secure, store, suggest, summarize, reach, translate and watch.

SUMMARY

The word **'Artificial'** means making, a copy of something natural and **'Intelligence'** means the ability to gain and apply knowledge and skills. Kurzweil, in 1990, defined AI as the art of creating machines that perform functions that require intelligence when performed by people. **But please remember that humans are much more intelligent than AI system** as we (humans) only program these AI applications (called as AI programs now). Also, we found that the idea of AI originated from a historic experiment called as Turing Test.

MULTIPLE CHOICE QUESTIONS [MCQ]

1. The branch of computer science dealing with symbolic and non-algorithmic method of problem solving is called as—
(*a*) Knowledge (*b*) AI (*c*) Meta-knowledge (*d*) None of there

2. Robotics is a type of—
(*a*) Mundane task (*b*) Formal task (*c*) Expert task (*d*) None of there

3. The birth of AI took place in—
(*a*) 1950s (*b*) 1960s (*c*) 1970s (*d*) 1980s

4. Which of the following expert systems was designed to infer the structure of organic molecules from their chemical formulas ?
(*a*) DENDRAL (*b*) MYCIN (*c*) PROSPECTOR (*d*) None of there

5. An average human brain has
(*a*) 10^{10} neurons (*b*) 10^{11} neurons (*c*) 10^{12} neurons (*d*) None of there

6. The steps to solve a quadratic equation are expressed as a—
(*a*) Procedural knowledge (*b*) Relational knowledge
(c) Heuristics knowledge (*d*) None of there

7. Feigenbaum and Mc-Corduck differentiated between —
   (*a*) Intelligence and AI (*b*) AI and IA
   (*c*) Knowledge and data (*d*) None of there
8. The study of the nature of knowledge is called as —
   (*a*) Epistemology (*b*) Ontology (*c*) Agent (*d*) None of there
9. Which of the following is larger?
   (*a*) KB (*b*) DB (*c*) Student database (*d*) None of there
10. The idea of AI originated from —
   (*a*) Turing Test (*b*) Chemical Test
   (*c*) Biological Test (*d*) None of there
11. Agents are —
   (*a*) autonomous (*b*) adaptive (*c*) Both 'a' and 'b' (*d*) None of there
12. The problems that AI tackles have —
   (*a*) Very little amount of solutions
   (*b*) Same number of solutions as our conventional programms have
   (*c*) Combinatonia explosion of solutions
   (*d*) None of the above
13. An AI program uses a technique —
   (*a*) Binary Search (*b*) Heuristic Search
   (*c*) Algorithmic Search (*d*) None of there
14. A set of all possible states for a given problem is known as —
   (*a*) State space (*b*) Table space (*c*) Reduction space (*d*) None of there
15. Which of the following are more intelligent?
   (*a*) Humans (*b*) AI systems (*c*) Expert systems (*d*) None of there

ANSWERS

1. (*b*)	2. (*a*)	3. (*a*)	4. (*a*)	5. (*c*)
6. (*a*)	7. (*c*)	8. (*a*)	9. (*b*)	10. (*a*)
11. (*c*)	12. (*c*)	13. (*b*)	14. (*a*)	15. (*a*)

CONCEPTUAL SHORT QUESTIONS WITH ANSWERS

Q. 1. Differentiate between Intelligence and Artificial Intelligence.

Ans. Let us tabulate the differences between the two —

Intelligence	Artificial Intelligence
1. It is a natural process.	1. It is programmed by humans.
2. It is actually hereditary.	2. It is not hereditary.
3. Good knowledge is required for intelligence.	3. KB is required to generate output.

4. No electricity from outside is required.	4. We need electrical energy to get output.
5. No human is an expert. We may get better solutions from other humans.	5. Expert systems are made which aggregate many persons experiences and ideas.

Q. 2. How is strong AI different from weak AI?

Ans. Let us tabulate the differences between them —

Strong AI	Weak AI
1. A strong AI claims that computers can be made to think on a level at least equal to humans.	1. A weak AI claims that some "thinking like" features are added to computer to make them more useful tool.
2. It deals with the creation of some form of computer-based AI that can truly reason and solve problems.	2. It deals with the creation of some form of computer-based AI that can reason and solve problems in a limited domain.
3. In strong AI, the programs are themselves the explanations.	3. A machine need not possess true intelligence.
4. "*Doing*" is sometimes referred to as strong AI.	4. "*Helping*" is called as weak AI.
5. We have still to achieve the objectives of strong AI.	5. We have already reached the objectives of weak AI.

Q. 3. Define what is a rational agent.

Ans. A rational agent is a type of agent that acts to achieve the best outcome or when there is uncertainty then to achieve the best expected outcome.

Q. 4. Define the following terms:

(*a*) Fuzzy Logic

(*b*) Planning

(*c*) Problem Space.

Ans. **(*a*) Fuzzy Logic**

A logic in which the truth values are real values in the closed interval [0 .....1] is called as a fuzzy logic. It uses the definitions of boolean operators to fit this continuous domain.

(*b*) Planning

A field of AI concerned with systems that construct sequences of action to achieve goals in real world like environments.

(*c*) Problem Space/State Space

The formulation of an AI problem into states and operators. We have a start state and a goal state. The problem space is searched to find a solution.

Q. 5. What are the major components of an AI system?

Ans. Any AI system has four main components and are shown in Fig. 1.7.

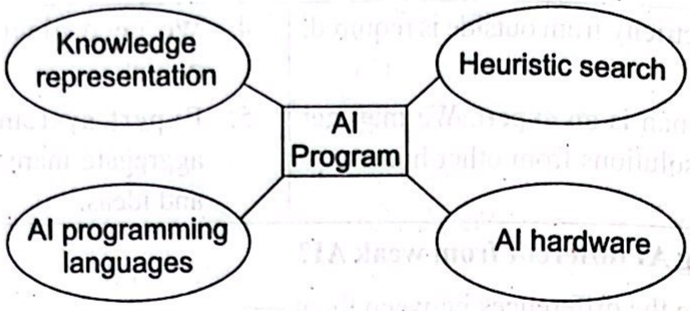

Fig. 1.7

Please understand that in AI system the quality of result depends upon how much knowledge the system possesses. The knowledge so available is to be represented in an efficient manner. The inferencing process has to be best. AI programs are written in specialized languages like Turbo-Prolog and LISP. **Also note that most of the AI programs are implemented on conventional Von Neumann machines only.** Today, even dedicated workstations have also emerged for AI programming.

Q. 6. What an agent comprises of?

Ans. We simply put it in an equation form, i.e.,

$\boxed{\text{Agent} = \text{architecture} + \text{program}}$

The **architecture** makes the percepts from the sensors available to the program, runs the program and feeds the program's action choices to the actuators as they are generated. So, the program we choose has to be one that is appropriate for the architecture.

Q. 7. What are the various task environments?

Ans. Basically, 6 types of task environments can be found for various problems.

(*a*) Fully observable v/s partially observable.

(*b*) Deterministic v/s stochastic.

(*c*) Episodic v/s sequential.

(*d*) Static v/s Dynamic.

(*e*) Discrete v/s Continuous.

(*f*) Single agent v/s multi-agent.

I. Fully observable v/s Partially observable

A task environment is fully observable if an agent's sensor gives it a complete access to the state of environment at each point of time. **For example,** a chess with a clock is fully observable environment.

On the other hand, an environment is partially observable because of noisy and inaccurate sensors. **For example,** an automated taxi cannot see what other drivers are thinking.

II. Deterministic v/s Stochastic

If the next state of the environment is completely determined by the current state and the action is executed by the agent then the environment is **deterministic** else it is **stochastic** environment. **For example,** Image analysis provides a deterministic environment whereas Taxi driving is a stochastic case.

III. Episodic v/s Sequential

In episodic task environment, the agent's experience is divided into atomic episodes. Each episode consists of the agent perceiving and then performing a single action. **For example,** image analysis would give episodic environment, while in sequential environments the current decision could affect all future decisions. **For example,** chess and taxi driving are sequential. **Please note that episodic environments are much simpler than sequential environments because the agent does not need to think ahead.**

IV. Static v/s Dynamic

If the environment can change while an agent is deliberating, then we say the environment is **dynamic** for that agent else it is **static. For example,** Taxi driving is dynamic. Crossword puzzles are static. Chess with clock is semi-dynamic.

V. Discrete v/s Continuous

A discrete or continuous distinction can be applied to the state of the environment and to the percepts and actions of the agent. **For example,** Taxi driving is continuous state problem whereas chess with a clock is discrete.

VI. Single Agent v/s Multiagent

These environments are easy to distinguish. **For example,** an agent solving a crossword puzzle by itself is clearly in a single agent environment, whereas playing chess with a clock is a multiagent environment.

EXERCISE QUESTIONS

Q. 1. (*a*) If the Turing Test is passed, does this show that computer exhibits Intelligence? State reasons.

(*b*) How declarative knowledge is different from procedural knowledge?

(*c*) Discuss the importance of heuristics in problem solving.

[GGSIPU, B.Tech (CSE)—8th sem., May-June 2009]

Q. 2. Compare knowledge representation to data representation in a database.

[GGSIPU, B.Tech (CSE)—8th sem., May-June 2009]

Q. 3. What is Turing's Test? Explain its significance.

[GGSIPU, B.Tech (CSE)—8th sem., May 2008]

Q. 4. Define AI. List important task domains of AI.

[GGSIPU, B.Tech (CSE)—8th sem., Sept. 2005]

Q. 5. What is AI? What are its application areas? **[GGSIPU, B.Tech (IT)—7th sem., 2007-08]**

Q. 6. What do you mean by knowledge acquisition?

[GGSIPU, B.Tech (IT)—8th sem., 2nd Internal Test, April 2008]

Q. 7. What is the role of Heuristics in AI? **[GGSIPU, MCA—4th sem., June 2001]**

Q. 8. Write different approaches of knowledge representation.

[GGSIPU, MCA—4th sem., May 2002]

Q. 9. "An AI system must contain a lot of knowledge if it is to handle anything but trivial problems but with the growth of knowledge it becomes harder to access appropriate information." Discuss this dilemma as encountered in AI systems.

[GGSIPU, MCA—4th sem., May 2003]

Q. 10. Term 'AI' is a misnomer. Comment. **[GGSIPU, MCA—4th sem., May 2004]**

Q. 11. In what context did Turing suggest his well-known test? Explain the Turing Test. **[GGSIPU, MCA—4th sem., May 2005]**

Q. 12. Define AI. What are its application areas? **[GGSIPU, BCA—5th sem., Dec. 2001]**

Q. 13. Write short notes on application of AI. **[GGSIPU, BCA—7th sem., Dec 2001]**

Q. 14. Can a system engaged in purely numeric computation be called an intelligent system? Explain with suitable arguments. **[IGNOU, MCA—3rd sem., June 2004]**

Q. 15. Explain the difference between the following terms — Knowledge and data. **[DU-DCE, ME (CS), 2005]**

Q. 16. What is AI? Briefly explain KBS? **[KUD, BE. (CSE)—8th sem., Ist Internal Test, March 1997]**

Q. 17. Describe knowledge representation and knowledge acquisition? **[KUD, B.E. (CSE)—8th sem., 1996]**

Q. 18. Define and describe the difference between knowledge, hypothesis, belief and data. Also discuss the differences between declarative and procedural knowledge. **[KUD, B.E. (CSE)—8th sem, 1997]**

Q. 19. What is AI? Write various areas of AI. **[UPTU, B.Tech (CSE)—8th sem., 2006-07]**

Q. 20. (*a*) How does AI solve problems for which no practically feasible algorithm exists?
(*b*) Discuss the scope of AI applied to various categories of problems. **[GGSIPU, B.Tech (CSE)—8th sem., May 2011]**