1 Artificial Intelligence - The Concept

Syllabus

What is AI ? : The AI Problems, The Underlying Assumption, What is an AI Techniques, The Level Of The Model, Criteria For Success, Some General References, One Final Word.

Contents

1.1 The Concept of Artificial Intelligence (AI)

GTU : Winter-12,14,16,17,19, Summer-18,20

1.1.1 Introduction

- Many human mental activities such as developing computer programs, working out mathematics, engaging in commonsense reasoning, understanding languages and interpreting it, even driving an automobile are said to demand "intelligence". Several computer systems have been built that can perform tasks such as these. Also there are specially developed computers systems that can diagnose disease, solve quadratic equations, understand human speech and natural language text.
- We can say that all such systems possess certain degree of artificial intelligence.
- The central point of all such activities and systems is that "How to think" OR rather "How to make system think". The process of thinking has various steps like preceive, understand, predict and manipulate a world that is made up of tiny complex things or situations.
- The field of AI not just attempts to understand but also it builds intelligent entities.

1.1.2 Various Definitions of AI

1. AI may be defined as the branch of computer science that is concerned with the automation of intelligent behaviour. (Luger - 1993)
2. Systems that thinks like human.
3. The exciting new effort to make computers think ... machines with minds, in the full and literal sense. (Hallgeland - 1985)
4. "The automation of activities that we associate with human thinking, activities such as devision making, problem solving, learning ..." (Bellman - 1978)
5. Systems that act like humans.
6. "The art of creating machines that perform functions that require intelligence, when performed by people". (Kurzweil - 1990)
7. "The study of how to make computers do things at which, at the moment, people are better". (Rich and Knight - 1991).
8. Systems that think rationally.
9. The study of mental faculties through the use of computational models. (Charniak and McDermott - 1985)

10. "The study of the computations that make it possible to perceive, reason and act". (Winston - 1992)
11. Systems that act rationally
12. "Computational intelligence is the study of the design of intelligent agents". (Poole et al - 1998)
13. "AI is concerned with intelligent behaviour in artifacts". (Nilsson - 1998)

- These definitions vary along two main dimensions. First dimension is the thought process and reasoning and second dimension is the behaviour of the machine.
- The first seven definitions are based on comparisons to human performance where as remaining definitions measure success against an ideal concept of intelligence, which we call **rationality**. A system is rational if it does the "right thing" given what it knows. Historically, there are four approaches that are followed in AI. These four approaches are **Acting Humanly, Thinking Humanly, Thinking Rationally** and **Acting Rationally**. **Let us consider four approaches in detail.**

1) Acting Humanly

- **Turing Test :** For testing intelligence **Alan Turing** (1950) proposed a test called as Turing test. He suggested a test based on common features that can match with the most intelligent entity - human beings.

Computer would need to possess following capabilities :

a) Natural language processing - To enable it to communicate successfully in English.

b) Knowledge representation to store what it knows, what it hears.

c) Automated reasoning to make use of stored information to answer questions being asked and to draw conclusions.

d) Machine learning to adapt to new circumstances and to detect and make new predictions by finding patterns.

- Turing also suggested to have physical interaction between interrogater and computers. Turing test avoids this but Total Turing Test includes video signal so that the interrogator can test the subject's perceptual abilities, as well as the opportunity for the interrogator to pass the physical objects "through the hatch".
- To pass total turing test in addition, computer will need following capabilities.

e) Computer vision to perceive objects.

f) Robotics to manipulate objects.

2) Thinking Humanly

- As we are saying that the given program thinks like human it we should know that how human thinks. For that, the theory of human minds needs to be

explored. There are two ways to do this : through introspection i.e. trying to catch our own thoughts as they go by and through psychological experiments.

- If computer programs, I/O and timing behaviours matches corresponding human behaviours, that is, we can say that some of the program's mechanisms could also be operating in human. The interdesciplinary field of cognitive science brings together computer models from AI and experimental techniques from psychology that try to construct precise and testable theories of the workings of human mind.

3) Thinking Rationally - the "laws of thought approach"

- The concept of "Right thinking" was proposed by Aristotle. This idea provided patterns for argument structures that always yielded correct conclusions when given correct premises.

For example, "Ram is man",
"All men are mortal",
"Ram is mortal".

- These laws of thought were supposed to govern the operation in the mind; their study initiated the field called **logic** which can be implemented to create intelligent systems.

4) Acting Rationally

- An **agent** (Latin **agre-to do**) is something that acts. But computer agents are expected to have more other attributes that distinguish them from just the "programs", because they need to operate under autonomous control, perceiving their environment, persisting over a prolonged time period, adapting to change and being capable of taking on another goals. A rational agent is expected to act so as to achieve the best outcome or when there is uncertainity to acheive best expected outcome.
- The laws of thought emphasis on correct inference which should be incorported in rational agent.

1.1.3 The Foundation of AI

- Now we discuss the various disciplines that contributed ideas, viewpoints and techniques to AI.
- **Philosophy** provides base to AI by providing theories of relationship between physical brain and mental mind, rules for drawing valid conclusions. It also provides information about knowledge origins and the knowledge leads to action.
- **Mathematics** gives strong base to AI to develop concrete and formal rules for drawing valid conclusions, various methods for date computation and techniques to deal with uncertain information.

- **Economics** support AI to make decisions so as to maximize payoff and make decisions under uncertain circumstances.
- **Neuroscience** gives information which is related to brain processing which helps AI to develope date processing theories.
- **Phychology** provides strong concepts of how humans and animals think and act which helps AI for developing process of thinking and actions.

1.1.4 The Strong and Weak AI

- After taking brief look at various disciplines that contribute towards AI, now let us look at the concept of strong and weak AI which also gives basic foundation for developing automated systems.

1.1.4.1 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,
- Human-like AI - In which the computer program thinks and reasons much like a human-mind.
- Non-human-like AI - In which the computer program develops a totally non-human sentience, and a non-human way of thinking and reasoning.

1.1.4.2 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.

1.1.5 What AI can do Today ?

1.1.5.1 Autonomous Planning and Scheduling

- NASA's Remote Agent program became the first on-board autonomous planning program to control the scheduling of operations for spacecraft. Such remote agents can do task of detecting, diagnosing and recovering from problems as they occurred.

1.1.5.2 Game Playing

- A computer chess program by IBM named as Deep Blue defeated world chess champion Garry Kasparov in exhibition match in 1997. Such type of gaming programs can be developed using AI techniques.

1.1.5.3 Autonomous Control

- The ALVINN computer vision system was trained to stear car to keep it following a lane. It was made to travel 2850 miles in which 98 % of the time control was with the system and only 2 % of the time human took over. AI can give more theories to develop such systems.

1.1.5.4 Diagnosis

- Heckerman (1991) describes a case where a leading expert on lymph node pathology scoffs at a program's diagnosis of an difficult case. The machine can explain the diagnosis. The machine points out the major factors influencing its decision and explain interaction of several of the symptoms in this case. If such diagnostic programs are developed using AI then highly accurate dignosis can be made.

1.1.5.5 Logistic Planning

- In 1991 during the persion Gulf Crisis U.S. forces deployed a dynamic analysis and replanning tool name DART for automated logistics planning and scheduling for transportation.
- AI can provide techniques for making fast and accurate plans.

1.1.5.6 Robotics

- For doing complex and critical tasks systems can be developed using AI techniques.
- For e.g. Surgeons can use robot assistants in microsurgery which can generate 3D vision of patients internal anatomy.

1.1.5.7 Language Understanding and Problem Solving

- PROVERB is computer program which expert in solving crossword puzzles.
- It can make use of constraints or possible word fillers, a large database of past puzzles and variety of information sources including dictionaries and online databases. Such as a list of movies and the actors that appears in them.
- AI does not generate magic or science fiction but rather it can develops science, engineering and mathematics system.
- Recent progress in understanding the theoretical basis for intelligence has gone hand in hand with improvements in the capabilities of real systems. The subfields of AI have became more integrated and AI has found common ground with other disciplines.

1.1.6 Human Vs Machine

1.1.6.1 Will Machine behave Exactly as Human ?

- Here are the considerable difference between human and machine.
  1) Machines do not have life, as they are mechanical. On the other hand, humans are made of flesh and blood; life is not mechanical for humans.
  2) Humans have feelings and emotions and they can express these emotions. Machines have no feelings and emotions. They just work as per the details fed into their mechanical brain.
  3) Human can do anything original and machines cannot.
  4) Humans have the capability to understand situations and behave accordingly. On the contrary, machines do not have this capability.
  5) While humans behave as per their consciousness, machines just perform as they are taught.
  6) Humans perform activities as per their own intelligence. On the contrary, machines only have an artificial intelligence.

1.1.6.2 Comparisons between Human and Machines

1) Brains are analogue ; machines are digital.
2) The brain uses content-addressable memory; In machine, information in memory is accessed by polling its precise memory address. This is known as byte-addressable memory.
3) The brain is a massively parallel machine ; machines are modular and serial.
4) Processing speed is not fixed in the brain; machine has fixed speed specification.
5) Brains short - term memory is not like RAM.

6) No hardware / software distinction can be made with respect to the brain or mind.

7) Synapses are far more complex than electrical logic gates.

8) Unlike machine, processing and memory management are performed by the same components in the brain.

9) The brain is a self - organizing system.

10) Brain have bodies, the brain is much, much digger than any [current] machine.

1.1.7 List of Expert Systems Influential in AI Field

1. MACSYMA - Advised the user on how to solve complex maths problems.
2. DENDRAL - Advised the user on how to interpret the output from a mass spectrograph.
3. CENTAUR, INTERNIST, PUFF, CASNET - Are all medical expert systems for various purposes.
4. DELTA - Locomotive engineering.
5. Drilling Advisor - Oilfield prospecting.
6. Exper Tax - Tax minimisation advice.
7. XSEL - Computer sales.
8. PROSPECTOR - Interpreted geological data as potential evidence for mineral deposits. (Duda, Hart, in 1976).
9. NAVEX - Monitored radar data and estimated the velocity and position of the space shuttle. (Marsh, 1984)
10. R1/XCON - Configured VAX computer systems on the basis of customer's needs. (Mc Dermott, 1980)
11. COOKER ADVISER - Provides repair advice with respect to canned soup sterilizing machines. (Texas Instruments, 1986)
12. VENTILATOR MANAGEMENT ASSISTANT - Scrutinised the data from hospital breathing - support machines, and provided accounts of the patient's conditions. (Fagan , 1978)
13. MYCIN - Diagnosed blood infections of the sort that might be contracted in hospital.
14. CROP ADVISOR - Developed by ICI to advise cereal grain farmers on appropriate fertilizers and pesticides for their farms.
15. OPTIMUM - AIV - is a planner used by the European Space Agency to help in the assembly, integration and verification of spacecraft.

1.2 AI Problem

GTU : Winter-12

- Much of the early work in AI focused on formal tasks, such as game playing and theorem proving. For example chess playing, logic theorist was an early attempt to prove mathematical theorems. Game playing and theorem proving share the property that people who do them well are considered to be displaying intelligence.
- Despite this it appeared that computers could perform well at those tasks by being fast at exploring a large number of solution paths and then selecting the best one. But no computer is fast enough to overcome the combinatorial explosion generated by most problems.
- AI focusing on the sort of problem solving we do every day for instance, when we decide to get to work in the morning, often called commonsense reasoning. In investigating this sort of reasoning Newell, Shaw, and Simon built the General Problem Solver (GPS), which they applied to several commonsense tasks as well performing symbolic manipulations of logical expression. However no attempt was made to create a program with a large amount of knowledge about a particular problem domain. Only quite simple tasks were selected.
- As AI research progressed and techniques for handling larger amounts of world knowledge were developed in dealing with problem solving in specialized domains such as medical diagnosis and chemical analysis.
- Perception (vision and speech) is another area for AI problems. Natural language understanding and problem solving in specialized domain are other areas related to AI problems. The problem of understanding spoken language is perceptual problem and is hard to solve from the fact that it is more analog related than digital related. Many people can perform one or may be more specialized tasks in which carefully acquired expertise is necessary. Examples of such as tasks include engineering design, scientific discovery, medical diagnosis, and financial planning. Programs that can solve problems in these domains also fall under the aegis of Artificial Intelligence.
- The tasks that are targets of works in AI can be categorized as follows :
  1. Mundane tasks - Perception (Vision and Speech), Natural language (Understanding, Generation, Translation, Commonsense reasoning, Robot control)
  2. Formal tasks - Games (Chess, etc.), Mathematics (Geometry, Logic, Integral calculus, etc.)
  3. Expert tasks - Engineering (Design, Fault finding, Manufacturing planning), Scientific analysis, Medical diagnosis, Financial analysis

- A person who knows how to perform tasks from several of the categories shown in above list learn the necessary skills in a standard order. First perceptual, linguistic, and commonsense skills are learned. Later expert skills such as engineering, medicine, or finance are acquired. Earlier skills are easier and thus more amenable to computerized duplication than the later, more specialized one. For this reason much of the initial work in AI work was concentrated in those early areas.
- The problems areas where now AI is flourishing most as a practical discipline are primarily the domains that require only specialized expertise without the assistance of commonsense knowledge. Expert systems (AI programs) now are up for day-to-day tasks that aim at solving part, or perhaps all, of practical, significant problem that previously required high human expertise.

- When one is building a expert system, following questions need to be considered before one can progress further :
- What are the underlying assumptions about intelligence ?
- What kinds of techniques will be useful for solving AI problems ?
- At what level if at all can human intelligence be modelled ?
- When will it be realised when an intelligent program has been built ?

1.3 The Underlying Assumption

- A physical symbol system consists of a set of entities called symbols which are patterns that can occur as components of another entity called an expression. At an instant the system will contain a collection of these symbol structures. In addition the system also contains a collection of processes that operate on expressions to produce other expressions ; processes of creation, modification, reproduction and destruction. A physical symbol system is a machine that produces through time an evolving collection of symbol structures. Such a system is machine that produces through time an evolving collection of symbol structures.

Following are the examples of physical systems -

- **Formal logic :** The symbols are words like "and", "or", "not", "for all x" and so on. The expressions are statements in formal logic which can be true or false. The processes are the rules of logical deduction.
- **Algebra :** The symbols are "+", "×", "x", "y", "1", "2", "3", etc. The expressions are equations. The processes are the rules of algebra, that allow you to manipulate a mathematical expression and retain its truth.
- **A digital computer :** The symbols are zeros and ones of computer memory, the processes are the operations of the CPU that change memory.

- **Chess :** The symbols are the pieces, the processes are the legal chess moves, the expressions are the positions of all the pieces on the board

The physical symbol system hypothesis claims that both of these are also examples of physical symbol systems. Intelligent human thoughts are the symbols that are encoded in our brains. The expressions are **thoughts.** The processes are the mental operations of thinking. In a running **artificial intelligence** program the symbols are data, the expressions are more data and the processes are programs that manipulate the data.

The importance of the physical symbol system hypothesis is twofold. It is significant theory of the nature of human intelligence and it forms the basis of the belief that it is possible to build programs that can perform intelligent tasks which are currently performed by people.

1.4 What is an AI Technique ?

Intelligence requires knowledge but knowledge possesses less desirable properties such as, 1. It is voluminous. 2. It is difficult to characterize accurately. 3. It is constantly changing. 4. It differs from data by being organised in a way that corresponds to its application.

An AI 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 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.

In many AI domains people must supply the knowledge to programs in a form the people understand and in a form that is acceptable to the program. Knowledge can be easily modified to correct errors and reflect changes in real conditions. Knowledge can be widely used even if it is incomplete or inaccurate. Knowledge can be used to help overcome its own sheer bulk by helping to narrow the range of possibilities that must be usually considered.

Following are three important AI 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 the many unimportant ones that would otherwise overwhelm any process.

1.5 The Level of the Model

GTU : Winter-19

Before starting doing something, it is good idea to decide exactly what one is trying to do. One should ask following questions for self analysis : -

- What is the goal in trying to produce programs that do the tasks the same way people do ?
- Are we trying to produce programs that do the tasks the same way people do ? Or are we trying to produce programs that simply do the tasks in whatever way appears easiest ?

Efforts to build program that perform tasks the way people do can be divided into two classes. The first one are those that attempt to solve problems that do not really fit our definition of AI. i.e. problems that computer could easily solve. The second class attempt to model human performance are those that do things that fall more clearly within our definition of Ai tasks; they do things that are not trivial for the computer.

Reasons for modeling human performance for these kind of tasks :-

- To test psychological theories of human performance. E.g. PARRY program written for this reason, which exploited a model of human paranoid behaviour to simulate the conversational behaviour of a paranoid person.
- To enable computer to understand human reasoning. For example, for a computer to be able to read a news paper story and then answer question, such as "Why did Ravana lose the game ?"
- To enable people to understand computer reasoning. In many cases people are reluctant to rely on the output of computer unless they can understand how the machine arrived at its result.
- To exploit what knowledge we can collect from people.
- To ask for assistance from best performing people and ask them how to proceed in dealing with their tasks.

1.6 Criteria for Success

- One of the most important questions to answer in any scientific or engineering research project is "How will we know if we have succeeded ?". So how in AI we have to ask ourselves, how will we know if we have constructed a machine that is intelligent ? The question is hard as unanswerable question "What is Intelligence ?"
- To measure the progress we use proposed method known as Turing Test. Alan Turing suggested this method to determine whether the machine can think. To conduct this test, we need two people and the machine to be evaluated. One person act as interrogator, who is in a separate room from the computer and the other person. The interrogator can ask questions of either the person or computer by typing questions and received typed responses. However the interrogator knows them only as A and B and aims to determine which is the person and which is the machine. The goal of the machine is to fool the interrogator into

believing that it is the person. If the machine succeeds at this, then we will conclude that the machine can think.

1.7 Some General References

- **The early work that is now generally recognized as AI was done in the period of 1943 to 1955. The first AI thoughts were formally put by men McCulloch and Walter Pitts (1943). Their idea of AI was based on three theories, firstly basic phsycology (the function of neurons in the brain), secondly formal analysis of propositional logic and third was Turing's theory of computation.**
- Later Donald Hebb in 1949 demonstrated simple updating rule for modifying the connection strengths between neurons. His rule now called Hebbian learning which is considered to be great influencial model in AI.
- There were huge early day work that can be recognized as AI but Alan Turing who first articulated a complete vision of AI in his 1950 article named "Computing Machinery and Intelligence".
- **Real AI birth year is 1956 where in John McCarthy held workshop on automata theory, neural nets and study of intelligence** where other researchers also presented their papers and they come out with new field in computer science called AI.
- From 1952 to 1969 large amount of work was done with great success.
- **Newell and Simon's presented General Problem Solver (GPS) within the limited class of puzzles it could handle.** It turned out that the order in which the program considered subgoals and possible actions was similar that in which humans approached the same problems. GPS was probably the first program which has "thinking humanly" approach.
- **Herbert Gelernter (1959) constructed the Geometry Theorem Prover** which was capable of proving quite tricky mathematics theorem.
- **At MIT, in 1958 John McCarthy made major contributions to AI field :- development of HLL LISP which has became the dominant AI programing language.**
- **In 1958, McCarthy published a paper entitled Programs with Common Sense, in which he described the Advice Taker, a hypothetical program that can be seen as the first complete AI system.** Like the Logic Theorist and Geometry Theorem Prover. McCarthy's program was designed to use knowledge to search for solutions of problems.
- The program was also designed so that it could accept new axioms in the normal course of operation, thereby allowing it to achieve competence in new areas

without being reprogrammed. The Advice Taker thus embodied the central principles of knowledge representation and reasoning.

- **Early work building on the neural networks of McCulloch and Pitts also flourished.** The work of Winogard and Cowan (1963) showed how a large number of elements could collectively represent an individual concept, with a corresponding increase in robustness and parallelism. Hebb's learning methods were enhanced by Bernie Widrow (Widrow and Hoff, 1960; Widro, 1962), who called his networks adalines, and by Frank Rosenblatt (1962) with his perceptrons. Rosenblatt proved the perceptron convergence theorem, showing that his learning algorithm could adjust the connection strengths of a perception to match any input data, provided such a match existed.
- **In 1965, Weizenbaum's ELIZA program appeared to conduct a serious conversation on any topic by basically borrowing and manipulating the sentences given by a human.** None of the programs developed so far, had complex domain knowledge and were called 'weak' methods. Researchers realized that it was necessary to use more knowledge for more complicated, larger reasoning tasks.
- **The DENDRAL program was developed by Buchanan in 1969 and was based on these principles. It was a unique program that effectively used domain specific knowledge in problem solving. In the mid-1970's, MYCIN, a program developed to diagnose blood infections. It used expert knowledge to diagnose illnesses and prescribe treatments.** This program is also known as the first program, which addressed the problem of reasoning with uncertain or incomplete information.
- Within a very short time a number of knowledge representation languages were developed such as predicate calculus, semantic networks, frames and objects. Some of them are based on mathematical logic such as PROLOG. Although PROLOG goes back to 1972, it did not attract wide spread attention until a more efficient version was introduced in 1979.
- As the real, useful strong works on AI were put forward by researchers, AI emerged to be a big Industry.
- **In 1981, Japanese announced 5th generation project a 10-year plan to build intelligent computers running PROLOG. US also formed the Micro electronics and Computer Technology Corporation (MCC) for research in AI.**
- Overall the AI industry boomed from few million dollars in 1980 to billions of dollars in 1988. But soon after that AI industry had huge setback as many companies suffered as they failed to deliver on extra vagant promises.
- In late 1970s more research were done by psychologists on neural networks which continued in 1980s.

- In 1990s AI emerged as a science. In terms of methodology AI has finally come firmly under the scientific method. **In recent years approaches based on Hidden Markov Models (HMMS) have come to dominate the AI field. This model is based on two aspects one is rigorous mathematical model theory and second is, these models are generated by a process of training on a large corpus real speech data.**
- **Judea Pearl's (1988) Probabilistic Reasoning in Intelligent Systems led to a new acceptance of probability theory in AI.** Later Bayesian network was invented which can represent uncertain knowledge along with reasoning support.
- Judea Pearl, Eric Hovitz and David Hackerman in 1986 promoted the idea of normative expert systems that can act rationally according to the laws of decision theory.
- Similar but slow revolution have ocurred in robotics, computer vision and knowledge representation.
- **In 1987 a complete agent architecture called SOAR was work out by Allan Newell, John Laired and Paul Rosenbloom.** Many such agents were developed to work in big environment "Internet". **AI systems have become so common in web based applications that the "- bot" suffix has entered in everyday language.**
- AI technologies underlie many Internet tools, such as search engines, recommender systems and website.
- While developing complete agents it was realized that previously isolated subfields of AI need to reorganize when their results are to be tied together.
- **Today, in particular it is widely appreciated that sensory systems (vision, sonar, speech-recogonition, etc.) cannot deliver perfectly reliable information about the environment. Hence reasoning and planning systems must be able to handle uncertainity.** AI has been draw in to much closer contact with other fields such as control theory and economics, that also deal with agents.

1.8 AI Terms

1.8.1 Agents and it's Environment

- An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators.
- For example consider human as agent. Human has eyes, ears and other organs which are sensors. Hands, legs, mouth and other body part work as actuators.
- Lets consider another example of agent - Robot. A Robotic agent might have cameras, infrared rangefinders as sensors. Robot can have various motors for actuators.

More examples of agent

1. Agent : Software agent
   Sensors : Keystrokes, file contents and network packets.
   Actuator : Screen, writing files, network packet.
2. Agent : Internet shopping agent
   Sensors : HTML, DHTML, pages (text graphics script)
   Actuators : Forms, display to user, follow URL.

1.8.2 The AI Terminology

1) Percept

The term percept refers to the agent's perceptual inputs at any given instant.

Examples -

1) A human agent percepts "Bird flying in the sky "through eyes and takes its snap (photograph)".
2) A robotic agent perceive "Temperature of a boiler" through cameras and takes the control action.

2) Percept Sequence

An agent's percept sequence is the complete history of everything the agent has ever perceived. Agent has choice of action at any given instant and it can depend on the entire percept sequence agent has recorded. The change in the perception forms a historical case.

For example -

A robotic agent monitoring temperature of a boiler will be sensing it continuously and keep on maintaining the percept sequence. This percept sequence will help robotic agent to know how temperature fluctuates and action will be taken depending on percept sequence for controlling temperature.

3) Agent Function

It is defined as mathematical function which maps each and every possible percept sequence to a possible action.

This function has input as percept sequence and it gives output as action.

Agent function can be represented in a tabular form.

Example -

ATM machine is a agent, it display menu for withdrawing money, when ATM card is inserted. When provided with percept sequence **(1)** A transaction type and **(2)** PIN number, then only user **gets cash.**

4) Agent Program

When we want to develop a agent program we need to tabulate all the agent functions that describes any given agent. This can practically lead to infinite functions hence we need to put bound on the length of percept sequence that we need to consider. This table of functions of percept sequences and action will be external characteristics of the agent where as internally agent function for an intelligent agent will be implement by an agent program.

Note :

Agent function is an abstract mathematical description.

Agent program is a concrete implementation, running on the agent architecture.

1.8.3 Architecture of Agent

- The agent program runs on some sort of computing device, which is called the architecture. The program we choose has to be one that the architecture will accept and run. The architecture makes the percepts from the sensors available to the program, runs the program and feeds the program's action choices to the effectors as they are generated. The relationship among agents, architectures and programs can be summed up as follows :

  Agent = Architecture + Program

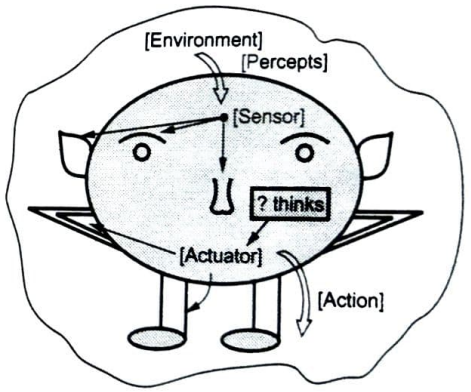


Fig. 1.8.1 Agent and its environment

1.8.4 Schematic of AI's Agent Performing Action

- Following diagram illustrates the agent's action process, as specified by architecture. This can be also termed as agent's structure.

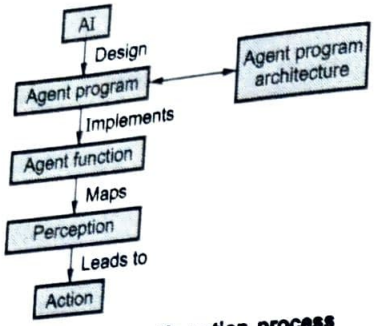


Fig. 1.8.2 Agent's action process

1.8.5 Role of An Agent Program

- An agent program is internally implemented as agent function.
- An agent program takes input as the current percept from the sensor and return an action to the effectors (Actuators).

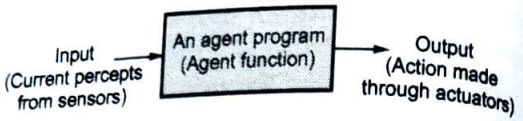


Fig. 1.8.3 Role of an agent program in agent architecture

1.8.6 Simple Example for Tabulation of a Agent

Agent - A shopping agent on internet called as bot.

Tabulation of percepts and action mapping -

Sr. No.	Sequence of Percepts	Actions
1.	[Type URL of greeting site mygreeting.com]	Display website.
2.	[Navigation and observation of greetings to be purchased]	Clicks on the link.
3.	[To get details of greeting (which is purchased), in terms of a form]	Form filling.
4.	[To perceive completion of process]	Receiving receipt or bill.

1.8.7 The Weak and Strong Agent

- An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors/actuators.

1.8.7.1 Weak Agent

- A weak notion says that an agent is a hardware or software based computer system that has the following properties :

1] Autonomy

Agents operate without direct intervention of humans and have control over their actions and internal state.

2] Social ability

Agents interact with other agents (and possibly humans) via an agent communication language.

3] Reactivity

Agents perceive their environment and respond in timely and rational fashion to changes that occur in it.

4] Pro - activeness

Agents do not simply act in response to their environment, they are capable of taking the initiative, generate their own goals and act to achieve them.

1.8.7.2 Strong Agent

A stronger nation says that an agent has mental properties, such as knowledge, belief, intention, obligation. In addition and agent has other properties such as : -

1. **Mobility :** Agents can move around from one machine to another and across different system architectures and platforms.
2. **Veracity :** Agents do not knowingly communicate false information.
3. **Rationality :** Agents will try to achieve their goals and not acts in such a way that would prevent their goals from being achieved.

Strong AI is associated with human traits such as consciousness, sentience, sapience, self-awareness

1. **Conciousness** - To have subjective experience and thought.
2. **Selfawareness** - To be aware of oneself as a separate individual, especially to be aware of one's own thoughts.
3. **Sentience** - The ability to feel perceptions and emotions subjectively.
4. **Sapience** - The capacity for wisdom.

1.8.8 Rational Behaviour and Omniscience

1.8.8.1 Rational Agent

- If every entry in the agent function is filled correctly then the agent will always do the right thing. Such agent is called as rational agent. Doing the right thing makes agent most successful. So now we need certain methods to measure the success of rational agent.
- When an agent is working in the environment, it generates a sequence of actions according to the percept it receives. This sequence of actions leads to various states of environment. If this sequences of environment state change is desirable, then we can say that agent has performed well. So if the tasks and environment change automatically the measuring conditions will change and hence there is no fixed measure suitable for all agents.
- As a general rule, it is better to design performance measures according to what one wants in the environment, rather than according to how one thinks the agent should behave.

The rationality depends upon 4 things -

1) The performance measure that defines the criterion of success.
2) The agent's prior knowledge about the environment.
3) The actions that the agent can perform.
4) The agent's percept sequence till current date.

Based on above 4 statements **rational agent can be defined as follows -**

For each possible percept sequence, a rational agent should select an action that is expected to maximize its performance measure given the evidence provided by the percept sequence and whatever built-in knowledge the agent has. Following figure depits performance measuremetric.

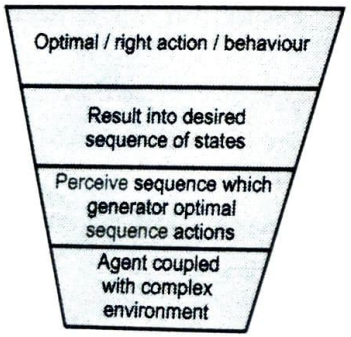


Fig. 1.8.4 Optimal performance triangle

1.8.8.2 The Good and the Bad Agent

- The concept of rational behaviour leads to two types agents, the good agents and the bad agent. Most of the time the good and bad behaviour (that is performance) of the agent depends completely on the environment.
- If environment is completely known then we get agent's good behaviour as depicted in Fig. 1.8.5.
- If environment is unknown then agent can act badly as depicted in Fig. 1.8.6.

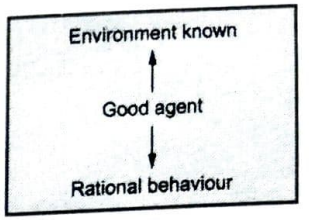


Fig. 1.8.5 Good agent

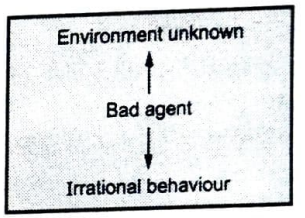


Fig. 1.8.6 Bad agent

1.8.8.3 Omniscience, Learning and Autonomy

- An omniscient agent knows the actual outcome of its actions and can act accordingly, but in reality omniscience is impossible.
- Rationality is not same as perfection. **Rationality maximizes expected performance where as perfection maximizes actual performance.**
- For increasing performance agent must do same actions in order to modify future percepts.
- This is called as information gathering which is important part of rationality. Also agent should explore (understand) environment to increase performance i.e. for doing more correct actions.
- Learning is another important activity agent should do so as to gather information. Agent may know environment completely (which is practically not possible) in certain cases but if it is not known agent needs learn on its own.
- To the extent that an agent relies on the prior knowledge of its designer rather than on its own percepts, we say that agent lacks autonomy. A rational agent should be autonomous - it should learn what it can do to compensate for partial or incorrect prior knowledge.

Figure Depicting rationality and Omniscience Relationship

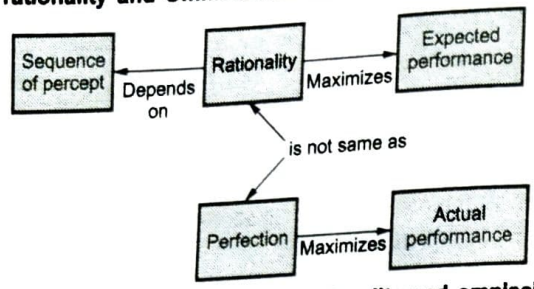


Fig. 1.8.7 The relationship between rationality and omniscience

1.8.9 Agent and it's Environment

1.8.9.1 Agent Description

Consider following example, A BLACK BALLS PICKER

The Picker World (Environment)

It is a simple and made-up world so one can invent many variations.

It has two buckets at two locations, L1 and L2 (for simplicity consider square area for location), full of BLACK and WHITE colour balls.

The Picker and its Perceptions

Picker perceives at which location it is. It can perceive that, is there a BLACK ball at the given location.

The Agent Actions

Picker can choose to MOVE LEFT or MOVE RIGHT, PICK UP BLACK BALL or be ideal that as do nothing.

A function can be devised as follows - if the current location bucket has more BLACK BALLS then PICK, otherwise MOVE to other square.

Diagram Depicting Black Ball Picker

Following is the partial tabulation of a simple agent function for the black ball picker.

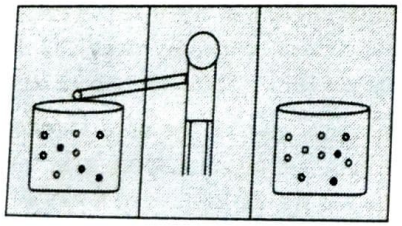


Fig. 1.8.8 Black ball picker world with two buckets at two locations

Percept Sequence	Action
[L1, No Black Ball]	Right
[L1, More Black Balls]	Pick
[L2, No Black Ball]	Right
[L2, More Black Balls]	Pick
:	
:	
[L1, No Black Ball], [L1, No Black Ball]	Right
[L1, No Black Ball], [L1, More Black Balls]	Pick
:	
:	
[L1 No Black Ball], [L1, No Black Ball],	
[L1, No Black Ball]	Right
[L1, No Black Ball], [L1, No Black Ball],	
[L1, More Black Balls]	Pick
:	
:	

1.9 The Environments

GTU : Winter-18,19, Summer-19

1.9.1 Nature of Environment

- In previous section we have seen various types of agents, now let us see the details of environment where in agent is going to work. A task environment is essentially a problem to which agent is a solution.
- The range of task environments that might arise in AI is obviously vast. We can, however, identify a fairly small number of dimensions along which task environments can be categorized. These dimensions determine, to a large extent, the appropriate agent design and the applicability of each of the principle families of techniques for agent implementation.

1.9.2 Types of Task Environment

1.9.2.1 Fully Observable Vs Partially Observable

- If an agent's sensors give it the access to the complete state of the environment at each point of time, then it is fully observable.
- In some environment, if there is noise or agent is with inaccurate sensors or may be some states of environment are missing then such environment is partially observable.

Example -

Fully Observable

The puzzle game environment is fully observable where agent can see all the aspects, that are surrounding it. That is agent can see all the squares of the puzzle game along with values (if any added) in them.

More examples -

1) Image analysis.

2) Tic - tac toe.

Partially Observable

The pocker game environment is partially observable. Game of pocker is a card game that shares betting rule ; and usually (but not always) hand rankings. In this game agent is not able to perceive other player's betting.

Also agent cannot see other player's card. It has to play with reference to its own cards and with current betting knowledge.

More examples -

1) Interactive Science Tutor.

2) Millitary Planning.

1.9.2.2 Deterministic Vs Stochastic

- If from current state of environment and the action, agent can deduce the next state of environment then, it is deterministic environment otherwise it is stochastic environment.
- If the environment is deterministic except for the actions of other agents, we say that the environment is **strategic**.

Examples -

Deterministic : In image analysis whatever is current percept of the image, agent can take next action or can process remaining part of image based on current knowledge. Finally it can produce all the detail aspects of the image.

Strategic : Agent playing tic-tac toe game is in strategic environment as from the current state agent decides next state action except for the action of other agents.

More examples -

1) Video analysis. 2) Trading agent.

Stochastic : Boat driving agent is in stochastic environment as the next driving does not based on current state. In fact it has to see the goal and from all current and previous percepts agent needs to take action.

More examples -

1) Car driving 2) Robot firing in crowd.

1.9.2.3 Episodic Vs Sequential

- In episodic environment agent's experience is divided into atomic episodes such that each episode consists of, the agent perceiving process and then performing single action. In this environment the choice of action depends only on the episode itself, previous episode does not affect current actions.
- In sequential environment on the other hand, the current decision could affect all future decision.
- Episodic environments are more simpler than sequential environments because the agent does not need to think ahead.

Example -

Episodic Environment : Agent finding defective part of assembled computer machine. Here agent will inspect current part and take action which does not depend on previous decisions (previously checked parts).

More Examples -

1) Blood testing for patient. 2) Card games.

Sequential Environment : A game of chess is sequential environment where agent takes action based on all previous decisions.

More examples -

1) Chess with a clock. 2) Refinery controller.

1.9.2.4 Static Vs Dynamic

- If the environment can change while agent is deliberating then we say the environment is dynamic for the agent, otherwise it is static.
- Static environments are easy to tackle as agent need not worry about changes around (as it will not change) while taking actions.
- Dynamic environments keep on changing continuously which makes agent to be more attentive to make decisions for act.
- If the environment itself does not change with time but the agent's performance does, then we say that environment is semidynamic.

Examples -

Static : In crossword puzzle game the environment that is values held in squares can only change by the action of agent.

More examples -

1) 8 queen puzzle. 2) Semidynamic.

Dynamic : Agent driving boat is in dynamic environment because the environment can change (A big wave can come, it can be more windy) without any action of agent.

More examples -

1) Car driving. 2) Tutor.

1.9.2.5 Discrete Vs Continuous

- In discrete environment the environment has fixed finite discrete states over the time and each state has associated percepts and action.
- Where as continuous environment is not stable at any given point of time and it changes randomly thereby making agent to learn continuously, so as to make decisions.

Example :

Discrete : A game of tic-tac toe depicts discrete environment where every state is stable and it associated percept and it is outcome of some action.

More examples -

1) 8 - queen puzzle. 2) Crossword puzzle.

Continuous : A boat driving environment is continuous where the state changes are continuous, and agent needs to perceive continuously.

More examples -

1) Part Picking Robot. 2) Flight Controller.

1.9.2.6 Single Agent Vs Multiagent

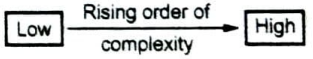
- In single agent environment we have well defined single agent who takes decision and acts.
- In multiagent environment there can be various agents or various group of agents which are working together to take decision and act. In multiagent environment we can have **competitive multiagent** environment, in which many agents are working parallel to miximize performance of individual or there can be **co-operative multiagent** environment, where in all agents have single goal and they work to get high performance of **all of** them together.

Example :

- Multiagent independent environment
  - ↳ Many agent in game of Maze.
- Multiagent cooperative environment
  - ↳ Fantasy football. [Here many agents work together to achieve same goal.]
- Multiagent competitive environment
  - ↳ Trading agents. [Here many agents are working but opposite to each other]
- Multiagent antagonistic environment
  - ↳ Wargames. [Here multiple agents are working opposite to each other but one side (agent/agent team) is having negative goal.]
- Single agent environment
  - ↳ Boat driving[Here single agent perceives and acts]

1.9.2.7 Complexity Comparison of Task Environment

Following is the rising order of complexity of various task environment.



Observable	→	Partially observable
Deterministic	→	Stochastic
Episodic	→	Sequential
Static	→	Dynamic
Discrete	→	Continuous
Single agent	→	Multiple agents.

1.9.3 More Types of Task Environment

Based on specific problem domains we can further classify task environments as follow.

1) Monitoring and Surveillance Environment

Example : Agent monitoring incoming people at some gathering where only authorized people are allowed.

2) Time Constrained Environment

Example : Chess with a clock environment where the move should be done in specified amount of time.

3) Decision Making Environment

Example : The executive agent who is monitoring profit of a organization, can help top level management to take decision.

4) Process Based Environment

Example : The image processing agent who can take input and synthesize it to produce required output, and details about the image.

5) Personal or User Environment

Example : A small scale agent which can be used as personal assistance who can help to remember daily task, who can give notifications about work etc.

6) Buying Environment

Example : A online book shopping bot (agent) who buys book online as per user requirements.

7) Automated Task Environment

Example : A cadburry manufacturing firm can use a agent who automates complete procedure of cadburry making.

8) Industrial Task Environment

Example : An agent developed to make architecture of a building or layout of building.

9) Learning Task Environment (Educational)

Example : We can have a agent who is learning some act or some theories presented to it and later it can play it back which will be helpful for others to learn that act or theories.

10) Problem Solving Environment

Example : We can have agent who solve different types of problems from mathematics or statistics or any general purpose problem like travelling salesman problem.

11) Scientific and Engineering Task Environment

Example : Agent doing scientific calculations for aeronautics purpose or agent develop to design road maps or over bridge structure.

12) Biological Task Environment

Example : Agent working for design of some chemical component helpful for medicine.

13) Space Task Environment

Example : Agent that is working in space for observing space environment and recording details about it.

14) Research Task Environment

Example : Agent working in a research lab where it is made to grasp (learn) knowledge and represent it and drawing conclusions from it, which will helps researcher for further study.

15) Network Task Environment

Example : An agent developed to automatically carry data over a computer network based on certain conditions like time limit or data size limit in same network (same type of agent can be developed for physically transferring items or mails) over same network.

16) Repository Task Environment

Example : If a data repository is to be maintained then agent can be developed to arrange data based on criterias which will be helpful for searching later on.

1.10 Different Types of Agents

1.10.1 Intelligent Agent

"Intelligent agent is an intelligent actor, who observe and act upon an environment".

Intelligent agent is magnum - opus.

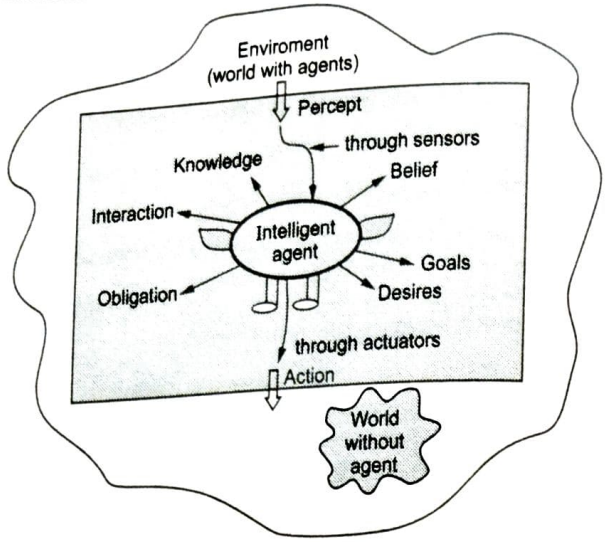


Fig. 1.10.1 Intelligent agent

The term 'Intelligent thinker' is different from intelligent agent. Fig. 1.10.2 shows intelligent agent's behaviour.

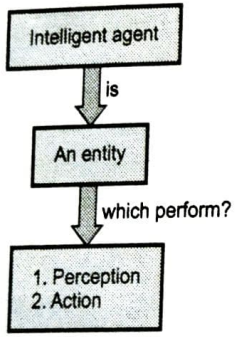


Fig. 1.10.2 Intelligent Agent

Example :

1) A robotic agent (Cameras, Infrared range finders).
2) An embedded real time software system agent.
3) A human agent (Eyes, ears and other organ).

Characteristics of Intelligent Agent (IA)

1) The IA must learn and improve through interaction with the environment.
2) The IA must adapt online and in the real time situation.

3) The IA must learn quickly from large amounts of data.
4) The IA must accommodate new problem solving rules incremently.
5) The IA must have memory which must exhibit storage and retrival capacities.
6) The IA should be able to analyze self in terms of behaviour, error and success.

1.10.2 Different Forms of Agents : (Types of Agents)

In artificial intelligence, there are different forms of intelligent agent and sub-agents.

As the degree of perceived intelligence and capability varies, it is possible to frame agent's into four categories.

1. Simple reflex agents.
2. Model based reflex agents.
3. Goal based agents.
4. Utility based agents.

In the following section we discuss each type of agent in detail.

1.10.2.1 Agent Type 1

Simple Reflex Agent

These agents select actions on the basis of the current percept, ignoring the rest of percept history.

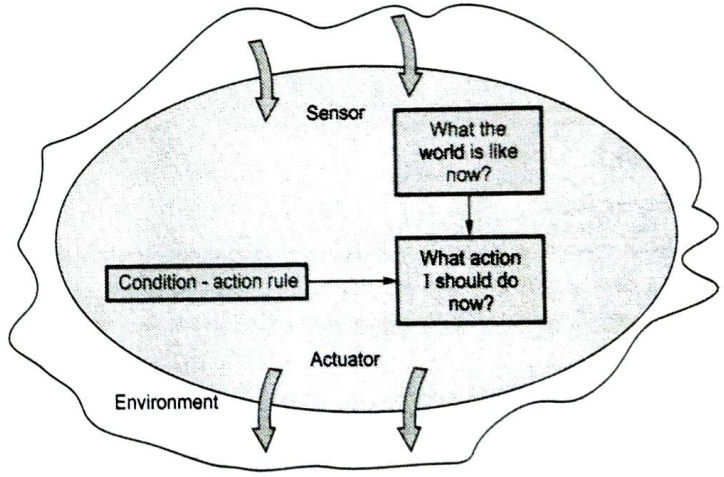


Fig. 1.10.3 Simple reflex agent

Property :

1) These are very simple but their intelligence is limited.
2) They will work only if correct decision can be made on the basis of only the current percept- that is only if the environment is fully observable.
3) A little bit of unobservability can cause serious trouble.
4) If simple reflex agent works in partially observable environment then, it can lead to infinite loops.
5) Infinite loops can be avoided if simplex reflex agent can try out possible actions i.e can randomize the actions.
6) A randomize simple reflex agent will perform better than deterministic reflex agent.

Example :

In ATM agent system if PIN matches with given account number then customer gets money.

Procedure : SIMPLE - REFLEX - AGENT

Input : Percept

Output : An action.

Static : Rules, a set of condition - action rules.

1. State ← INTERPRET - INPUT (percept)
2. rule ← RULE - MATCH (state, rules)
3. action ← RULE - ACTION (rule)
4. return action.

1.10.2.2 Agent Type 2

Model Based Reflex Agent

Internal state of the agent stores current state of environment which describes part of unseen world i.e how world evolves, and effect of agent's own actions. It means that it stores model of possibilities around it. Hence it is called as model based reflex agent.

Property :

1) It has ability to handle partially observable environments.
2) Its internal state is updated continuously which can be shown as :

Old - Internal state + Current percept = Update state.

For example :

A car driving agent which maintains its own internal state and then take action as environment appears to it.

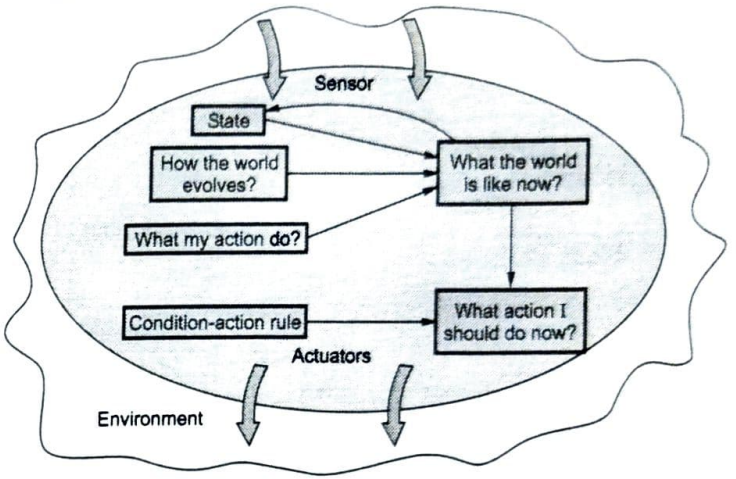


Fig. 1.10.4 Model - based reflex agent

Procedure : REFLEX-AGENT-WITH-STATE

Input : Percept

Output : An action.

Static : State, a description of the current world state, rules, a set of condition-action rules, action, the most recent action, initially none.

1. State ← UPDATE-STATE (state, action, percept)
2. Rule ← RULE-MATCH (state, rules)
3. Action ← RULE-ACTION (rule)
4. return action.

1.10.2.3 Agent Type 3

Goal Based Agent

Goal based agent stores state description as well as it stores goal states information.

Property

1) Goal based agent works simply towards achieving goal.
2) For tricky goals it needs searching and planning.

3) They are dynamic in nature because the information description appears in proper and explicit manner.
4) We can quickly change goal based agent's behaviour for new/unknown goal.

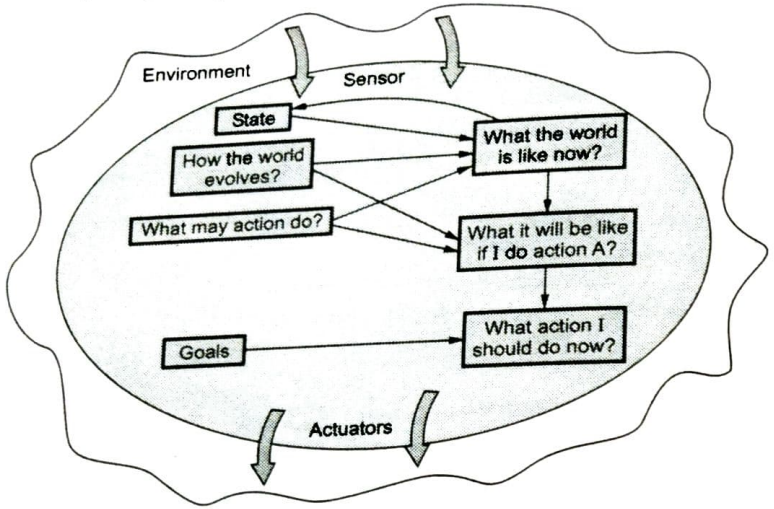


Fig. 1.10.5 Goal-based agent

For example :

Agent searching a solution for 8-queen puzzle.

1.10.2.4 Agent Type 4

Utility Based Agent

In complex environment only goals are not enough for agent designs. Additional to this we can have utility function.

Property :

1) Utility function maps a state on to a real number, which describes the associated degree of best performance.
2) Goals gives us only two outcomes achieved or not achieved. But utility based agents provide a way in which the likelihood of success can be measured against importance of the goals.
3) Rational agent which is utility based can maximize expected value of utility function i.e more perfection can be achieved.

4) Goals gives only two discrete states
   a) Happy b) Unhappy

For example -

Millitary planning robot which provides certain plan of action to be taken. Its environment is too complex, and expected performance is also high.

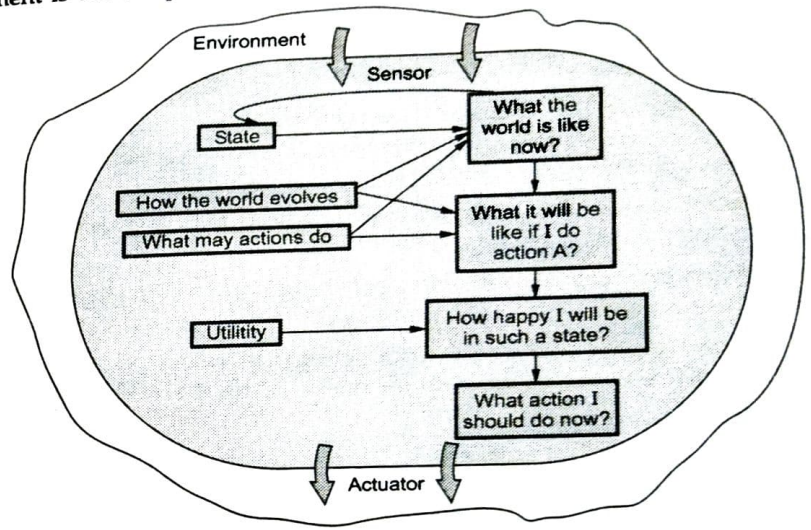


Fig. 1.10.6 Utility - based agent

1.10.3 The Learning Agent

If agent is to operate initially in unknown environments then agent should be self-learner. It should observe and gain and store information. Learning agent can be divided into 4 conceptual components

1) Learning Element - Which is responsible for making improvements.
2) Performance Elements - Which is responsible for selecting external actions.
3) Critic - It tells how agent is doing and determines how the performance element should be modified to do better in the future.
4) Problem Generator - It is responsible for suggesting actions that will lead to new and informative experiences to agent. Agent can ask problem generator for suggestions.

The performance standards distinguishes part of the incoming percept as a reward (success) or penalty (failure) that provides direct feedback on the quality of the agent's behaviour.

All four types agent we have seen can improve their performance through learning and there by become learning agents.

For example :

Aeroplane driving agent which continuously learns from environment and then do safe plane driving.

1.10.3.1 Components of Learning Agent

1) Base/Learner/Learning element - It holds basic knowledge and learn new things from the unfamiliar environment.
2) Capable/Efficient system/Performing elements - Capable system is responsible for selecting external actions. Performance element is the actual agent. It perceives and decides actions.
3) Fault reflector element - It gives feedback. It reflects fault and analyze corrective actions in order to get maximum success.
4) New problem generator element - It generate new and informative experience. It suggests new actions.

The performance standard makes difference between incoming percept as a reward (or penalty), that indicate direct feedback on the quality of the agent's behaviour.

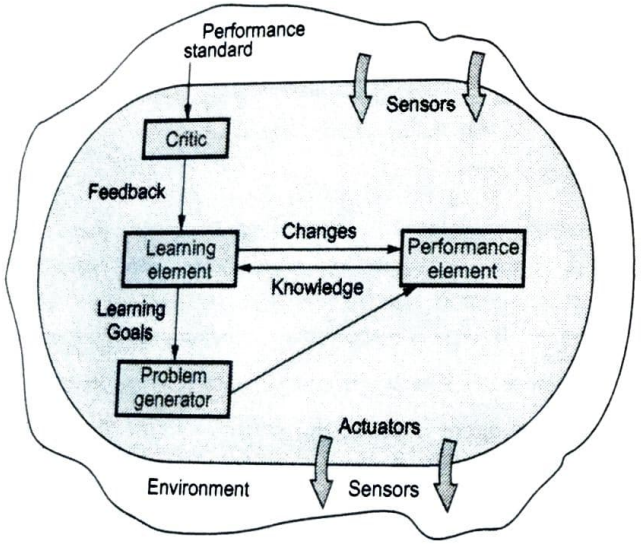


Fig. 1.10.7 Learning agent

1.10.4 More Types of Agents

We can do classification of agents based on various aspects like -

1) Task they perform. 2) Their various control architecture.
3) Depending on sensitivity of their sensors, and effectiveness of their action and internal states they possess.

Following are various types of agents, based on above classification criteria :-

1. **Physical Agents :** A physical agent is an entity which perceives through sensors and acts through actuators.
2. **Temporal Agents -** A temporal agent may use time based stored information to offer instructions or data acts to a computer program or human being and takes program inputs percepts to adjust its next behaviour.
3. **Spatial Agents -** That relate to the physical real-world.
4. **Processing Agents -** That solve a problem like speech recognition.
5. **Input Agents -** That process and make sense of sensor inputs- e.g. neural network based agents.
6. **Decision Agents -** That are geared upto do decision making.
7. **Believable Agents -** An agent exhibiting a personality via the use of an artificial character (the agent is embedded) for the interaction.
8. **Computational Agents -** That can do some complex, lengthy scientific computations as per problem requirements.
9. **Information Gathering Agents -** Who can collect (perceive) and store data.
10. **Entertaining Agents -** Who can perform something which can entertain human like gaming agents.
11. **Biological Agents -** Their reasoning engine works almost identical to human brain.
12. **World Agents -** That incorporate a combination of all the other classes of agents to allow autonomous behaviours.
13. **Life Like Agents -** Which are combinations of other classes of agents which will behave like real world characters. (For example - A robotic dog)

1.11 Designing an Agent System

When we are specifying agents we need to specify performance measure, the environment and the agent's sensors and actuators. We group all these under the heading of the task environment.

For the acronymically we call this PEAS ([P]erformance, [E]nvironment, [A]ctuators, [S]ensors) description.

1.11.1 The Steps in Designing an Agent

1) Define problem area (i.e. task environment) in complete manner. Example-Vaccum world, automated face recognition, automated taxi driver.
2) Define or tabulate PEAS.
3) Define or tabulate agent functions (i.e. percept sequence and action column)
4) Design agent program.
5) Design an architecture to implement agent program.
6) Implement an agent program.

The agent system may be single agent or multiple agents system.

If system is multiagents then we need to consider communication, co-operation strategies among multiple agents.

1.11.2 Examples of Agent Types and Their PEAS Description According to Their Uses

I) General Purpose (uses for common man)

Sr. No.	Agent Type	Performance Measure	Environment	Actuators	Sensors
1.	An automated taxi driver	Safe, fast, legal, comforatable trip, maximize profits.	Roads, other traffic, pedestrians, customers.	Steering acceleration break, Signal, horn, display.	Cameras, sonar, speedometer, GPS, Odometa, accele rometer engine, Sensors, keyboard.
2.	An automated face recognizer	Correct, recognition efficient system.	Human face software, web camera/video camera, infrared light.	Capturing face, feature extraction, classification.	Web/video camera, keyboard, mouse, infrared light.
3.	Part-picking robot	Percentage of parts in correct bins.	Conveyor belt with parts ; bins.	Jointed arm and hand.	Camera, joint angle sensors.
4.	ATM system	Secure, reliable fast service.	ATM machine, human system (customer).	Display menu/screen with options, validity checks.	Touch screen.

II) Industrial Business Purpose :

Sr. No.	Agent Type	Performance Measure	Environment	Actuators	Sensors
1.	E-commerce system	Secure reliable, fast business processing	E-commerce websites, human system. (customer).	Display product lists with price, forms.	Keyboard, mouse.
2.	Refinery controller	Maximize, purity, yield, safety.	Refinery, operators.	Values, pumps, heaters, displays.	Temperature, pressure, chemical sensors.

III) Scientific / Research Purpose

Sr. No.	Agent Type	Performance Measure	Environment	Actuators	Sensors
1.	Satellite image analysis system.	Correct image categorization	Downlink from orbiting satellite.	Display categorization of scene.	Color pixel arrays.
2.	Chemical reaction analyzer in chemistry research lab.	Correct recording of reaction.	A chemistry lab where instruments, chemicals are available for carrying out reactions.	Recording result of reaction.	Knowledge database of chemicals and their characteristics.

IV) Medical Purpose

Sr. No.	Agent Type	Performance Measure	Environment	Actuators	Sensors
1.	Medical diagnosis system.	Healthy patient, minimize costs, lawsuits	Patient, hospital, staff.	Display questions, tests, diagnoses, treatments, referrals.	Keyboard entry of symptoms, findings, patient's answers.
2.	Blood testing system.	Correct reporting on each test.	Blood sample lab.	Detail reporting of each test with specified components.	Database of procedures of test conduction and results.

V) Educational Purpose

Sr. No.	Agent Type	Performance Measure	Environment	Actuators	Sensors
1.	Interactive English tutor.	Maximize student's score on test.	Set of students, testing agency.	Display exercises suggestions, corrections.	Keyboard entry.
2.	A casio teacher.	Learner should be able to play specific musical pieces.	Group of learner or a single learner.	Display of each note, presentation of playing a key, sample music pieces.	Inputs from learner, from mouse or keyboard and database of casio details.

1.11.3 The Detail Example of PEAS

Agent : Interactive English Tutor

I) The [P]erformance Measures :

The Interactive English Tutor agent system must achieve the following performance measures.

1) All the student must get maximum knowledge regarding English subject, such as vocabulary, verbal soft skills, (i.e. communicational skill), reading, writing skills.
2) All the students must score good marks in the english test.

II) The [E]nvironment :

In Interactive English Tutor agent system environment has following properties :-

1) All the students having different grasping power and IQ (Intellectual Quotient).
2) Software modules which gives demonstration.

III) The [A]ctuators (Actions) :

The software model (agent program) will be executed on the agent architecture. (i.e. operating system). The actions performed by interactive english tutor are,

1) Audio / video demonstration on different topics.
2) Practical assignment on verbal written skills, report generation, letter writing, etc.
3) Monitoring and inspection (i.e. checking) of the practical assignment provided with suggestions and corrections, to students.
4) Online test conduction and result analysis.
5) Student's speech and video recording.

IV) The [S]ensors :

Sensor plays a crucial role in interactive English Tutor agent system. The following sensor are required to support sequence of perception :-

1) Keyboard for providing input events.
2) Mouse for GUI interface.
3) Headphone for listening and mike for audio recording.
4) Video/web camera's for video shooting.

1.12 One Final Word

- After taking a brief tour of AI history and its related work it can be seen that goal of AI is to construct working programs that solve the problems which are useful for well being of human.
- In AI major issue is to acquire large and enough amount of data and processed knowledge that can deal with almost all the problems and at least solve the toy problems. It becomes harder to access appropriate things when required, once the amount of knowledge grows up.
- A good programming language is required to process knowledge related to AI problems. LISP has been most commonly used language for AI programming. Specifically, AI programs are easiest to build using languages that have been designed to support symbolic rather than primarily numeric computation.
- AI is still a yet to bloom and a bud in industry. In our syllabus we are going to study some of the basic but major topics related to AI.

Answer in Brief

1. *Define AI.* **(Refer section 1.1)**
2. *What is AI ?* **(Refer section 1.1)**
3. *What is meant by robotic agent ?* **(Refer section 1.1)**
4. *What are advantages one can infer when machines perform intelligently ?* **(Refer section 1.1)**
5. *Define an agent.* **(Refer section 1.8)**
6. *What is role of an agent program ?* **(Refer section 1.8)**
7. *Define rotational agent.* **(Refer section 1.8)**
8. *List down the characteristics of intelligent agent.* **(Refer section 1.10)**
9. *Give general model of learning agent.* **(Refer section 1.10)**
10. *Explain in detail the history of AI.* **(Refer section 1.1)**
11. *What are various domains of AI ?* **(Refer section 1.1)**
12. *Discuss in detail the structure of agent with suitable diagram.* **(Refer section 1.8)**

13. *What is an ideal rational agent ?* **(Refer section 1.8)**
14. *Explain properties of environment.* **(Refer section 1.9)**
15. *Name at least 5 agent types with percepts actions and goals with environment.* **(Refer section 1.9)**
16. *What are requirements of intelligent agents ?* **(Refer section 1.10)**
17. *Discuss model based agents and goals based agents.* **(Refer section 1.10)**
18. *Give the structure of an agent with goals.* **(Refer section 1.10)**
19. *List few agent types and describe their PEAS.* **(Refer section 1.11)**
20. *What is meant by PEAS ?* **(Refer section 1.11)**
21. *What is AI ? Explain how an AI system is different from a convolutional computing system.* **(Refer section 1.1)**
22. *What is AI ? State various characteristics of AI.* **(Refer section 1.1)**
23. *Explain the nature and scope of AI. Why game playing problems are considered AI problems ?* **(Refer section 1.1)**
24. *What are AI techniques ?* **(Refer section 1.4)**
25. *Define AI and justify with suitable example how does conventional computing different from the intelligent computing.* **(Refer section 1.1)**
26. *Explain desirable properties of AI internal representation and AI software.* **(Refer section 1.1)**

1.13 University Questions with Answers

Winter - 12

Q.1 *What is intelligence ? Discuss types of problems requiring intelligence to solve it. Define AI.* **(Refer sections 1.1.2 and 1.2)** [7]

Winter - 14

Q.2 *Define AI ? Explain the characteristics of AI problem.* **(Refer section 1.1.2)** [7]

Winter - 16

Q.3 *Discuss following : i) Turing test* **(Refer section 1.1)** [3]

Winter - 17

Q.4 *Discuss : Turning test.* **(Refer section 1.1)** [3]

Summer - 18

Q.5 *Discuss Turning test.* **(Refer section 1.1)** [4]

Winter - 18

Q.6 *Define and discuss different task domain of artificial intelligence.* **(Refer section 1.9)** [3]

Summer - 19

Q.7 *Define the following words in the context of AI : Intelligence* **(Refer section 1.9)** [4]

Winter - 19

Q.8 *Define the term "Artificial Intelligence". Explain how AI techniques improve real-world problem solving.* **(Refer sections 1.1 and 1.4)** [3]

Q.9 *What is the significance of the "Turing Test" in AI ? Explain how it is performed.* **(Refer section 1.1)** [4]

Q.10 *Enlist and discuss the major task domains of Artificial Intelligence.* **(Refer section 1.9)** [7]

Summer - 20

Q.11 *Define the following words in the context of AI :*
i) Intelligence. **(Refer section 1.1)** [4]

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