Artificial Intelligence

Unit 1 Introduction to Intelligent System

Topic-1 Definition and What is AI???

It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.

It is the study of how to make computers do things which at the moment people do better. It fails to include some areas of potentially large impact namely problems that cannot now be solved well by either computers or people.

It is the automation of activities that we associate with human thinking, activities such as decision making, problem solving, learning .

Intelligence +System → AI

AI is the study of how to make computers do things at which at the movement people are better.

Human Intelligence VS Artificial Intelligence

Pros

Human Intelligence	Artificial Intelligence
• Intuition, Common sense, Judgement, Creativity, Beliefs etc • The ability to demonstrate their intelligence by communicating effectively • Plausible Reasoning and Critical thinking	• Ability to simulate human behavior and cognitive processes • Capture and preserve human expertise • Fast Response. The ability to comprehend large amounts of data quickly.

Cons

Human Intelligence	Artificial Intelligence
• Humans are fallible • They have limited knowledge bases • Information processing of serial nature proceed very slowly in the brain as compared to computers • Humans are unable to retain large amounts of data in memory.	• No "common sense" • Cannot readily deal with "mixed" knowledge • May have high development costs • Raise legal and ethical concerns

Artificial Intelligence VS Conventional Computing

Artificial Intelligence

- AI software uses the techniques of search and pattern matching
- Programmers design AI software to give the computer only the problem, not the steps necessary to solve it

Conventional Computing

- Conventional computer software follow a logical series of steps to reach a conclusion
- Computer programmers originally designed software that accomplished tasks by completing algorithms

Need for AI: To supplement natural intelligence for e.g we are building intelligence in an object so that it can do what we want it to do, as for example-- robots, thus ***reducing human labour and reducing human mistakes.***

Intelligent Systems in Your Everyday Life

- Post Office
  - automatic address recognition and sorting of mail
- Banks
  - automatic check readers, signature verification systems
  - automated loan application classification
- Customer Service
  - automatic voice recognition
- The Web
  - Identifying your age, gender, location, from your Web surfing
  - Automated fraud detection
- Digital Cameras
  - Automated face detection and focusing
- Computer Games
  - Intelligent characters/agents

Defining AI – 2 dimensions

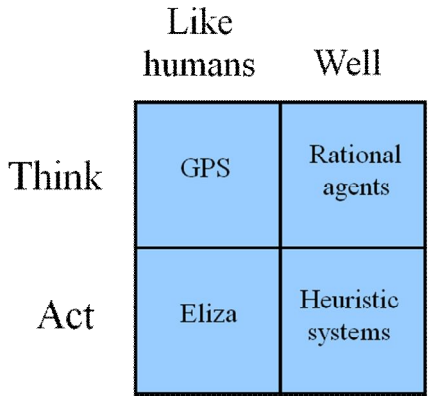
- ✓ Thought processes and reasoning
- ✓ Behaviour

Rationality means –> doing right things Rational agent – agent that does the right thing to achieve the best outcome

4 categories of AI definitions

- ✓ Systems that think like humans
- ✓ Systems that act like humans
- ✓ Systems that think rationally
- ✓ Systems that act rationally

Possible Approaches AI WORK ON Rational Agent and Heuristic Search



Think like humans

- Focus not just on behavior and I/O but also look at reasoning process.
- Computational model should reflect "how" results were obtained.
- Provide a new language for expressing cognitive theories and new mechanisms for evaluating them
- GPS (General Problem Solver): Goal not just to produce humanlike behavior, but to produce a sequence of steps of the reasoning process that was similar to the steps followed by a person in solving the same task.

Act like humans

- Not interested in how you get results, just the similarity to what human results are.
- Also interested in comparability to human behavior over correctness.
- The “Turing Test” approaches.

Think well

- Develop formal models of knowledge representation, reasoning, learning,memory, problem solving, that can be rendered in algorithms.
- There is often an emphasis on systems that are provably correct, and guarantee finding an optimal solution.

Act well

- For a given set of inputs, generate an output that gets the job done: achieve the best (expected) outcome.
- Depends on formal methods but also on heuristics as needed.
- A heuristic is a rule of thumb, simplification, or other device which drastically limits search for solutions in large problem spaces.
- Heuristics do not guarantee optimal solutions, but a useful heuristic offers solutions which are good enough most of the time.
  – Feigenbaum and Feldman, 1963, p. 6
- “Rational agent” approach, and the approach we will mostly follow.

So when WILL we decide that computers are intelligent? --→Using Turing Test

Topic-2 What is Turing Test Approach??? (Act like human)

- Three rooms contain a person, a computer, and an interrogator
- The interrogator can communicate with the other two by teleprinter.
- The interrogator tries to determine which is the person and which is the machine.
- The machine tries to fool the interrogator into believing that it is the person.
- If the machine succeeds, then we conclude that the machine can think.

- ✓ Operational definition of intelligence
- ✓ Human interrogator
- ✓ Capabilities needed for a computer to pass turing test
- ✓ Natural language processing
- ✓ Knowledge representation
- ✓ Automated reasoning
- ✓ Machine learning
- ✓ Computer vision
- ✓ robotics

Cognitive modelling approach (think like human)

- ✓ To determine how humans think
- ✓ Introspection – self-experiments
- ✓ Psychological experiments
- ✓ General problem solver
- ✓ Cognitive science
- ✓ Experimental investigation of humans and animals

Laws of thought approach(think rationally)

- ✓ Right thinking
- ✓ Reasoning process
- ✓ Syllogisms
- ✓ Ex:- Socrates is a man
  All men are mortal
  Socrates is mortal.
- ✓ Operation of mind
- ✓ Logic
- ✓ Rational Agent approach(act rationally)

Topic-3 Foundations of artificial intelligence

1.Philosophy

- Can formal rules be used to draw valid conclusions
- How does mental mind arise from a physical brain
- Where does knowledge come from
- How does knowledge lead to action
- Aristotile – syllogisms for reasoning
- Ramon lull – concept wheels
- Mechanical calculator
- Calculating machine

2. **Mathematics**
- What are the formal rules to draw valid conclusions
- What can be computed
- How do we reason with uncertain information
- Logic , computation, probability

3.**Economics**
- How should we make decisions so as to maximize payoff
- How should we do this when others may not go along
- How should we do this when the payoff may be far in the future
- Decision theory – probability theory+ utility theory

4.**Neuroscience**
- How do brain process information

5.**Psychology**
- How do humans and animals think and act
- Behaviourism

6.**Computer Engineering**
- How can we build an efficient computer

7. **Control Theory and Cybernetics**
- How can artifacts operate under their own control
- Control theory
- Cybernetics
- Objective function

8.**Linguistics**
- How does language relate to thought
- Computational linguistics

- Its main aim is depend upon the situation to take the decisions automatically.
- AI is the scientific research, this research will begin from past are years , are origin is JAPAN.
- AI is the part of the Computer Science Concerned with designing, intelligent computer systems, that is systems that exhibits the characteristics we associate with intelligence in Human Behavior. Once again this definition will raise the following question. “Intelligent Behavior “, in view of the difficulty in defining the Intelligence, Let us try to characteristics that is a list of number of characteristics by which we can identify the Human Intelligence .

1. To respond situations very flexibility.
2. To make sense of out of ambiguity to the are messages.
3. To recognize the relative importance of different elements of a situation.
4. To find similarities between situations despite the differences which my separate them.
5. To draw distinction between situations despite similarities which may link them. AI is the branch of Computer science dealing with symbolic non algorithmic methods of a problem solving.

AI is the branch of computer science that deals with ways of representing knowledge by using symbols rather are numbers and with rules of thumb, or heuristic methods for processing.

AI works with pattern matching methods which attempts to describe objects, events and processes in terms of their qualitative features and logical and computational relationships.

While reading the above definitions one must be remember keeping in mind that the AI is fast new developing science.

These are challenges now facing researchers in AI.

But AI researchers shown people are more Intelligent than Computers, AI tries to improve the performance of computers in activities that people do better, then the goal of AI is to make computers more Intelligent. AI researches have show that " Intelligence requires knowledge", and knowledge itself posses some less desirable activities of Real Life Situations.

It voluminous
It is hard characterize accurately
It is constantly changing
It differs from data
It is organized data

AI is the branch of computer science that deals with ways of representing knowledge by using symbols rather than numbers and with rules of thumb, or heuristic methods for processing.

AI works with pattern matching methods which attempts to describe objects, events and processes in terms of their qualitative features and logical and computational relationships. While reading the above definitions one must be remember keeping in mind that the AI is fast new developing science.

Thus it is having both Scientific and Engineering goals.
AI is the part of the Computer Science concerned with designing, intelligent computer systems, that is systems that exhibit the characteristics we associate with intelligence in Human Behavior. Once again this definition will raise the following question. "Intelligent Behavior ", in view of the difficulty in defining the Intelligence, Let us try to characterize that is a list of number of characteristics by which we can identify the Human Intelligence. It is related to the similar task of using computers to understand Human Intelligence.

The term AI is referred to known as Intelligent Behavior in Artifacts. Artifacts are Man-Made Machines. Thus AI is related with Psychology, Cognition, and Behavioral Science. Thus we have to consider the following Characteristics that are passed by an AI System
1. Perception
2. Reasoning
3. Learning
4. Communicating
5. Acting in Complex Environments.

These are the challenges now facing researchers in AI.

AI Languages

For developing the AI application the researchers use the two languages.
1. LISP – List Processing
2. PROLOG – PROgramming in LOGic.

LISP is used mainly in America for developing the AI application. PROLOG is used in Japan and the other Europe countries for develop the AI applications. Where as in image processing researchers use the natural computer languages FORTRAN & C.
In export systems the researchers use the "OOPS-5".

FIFTH GENERATION PROJECT:-

To identify the importance of "Artificial Intelligence" JAPAN start the FIFTH GENERATION PROJECT 14 years back. JAPAN government gave the permission to make the special computers for AI applications.

INDIAN IN FIFTH GENERATION PROJECT:-

INDIA also started FIFTH GENERATIN PROJECT 8 years back, for this INDIAN GOVERNMENT gave the permission to the IIT , ISI(Calcutta) ., IISI (Bangalore)., till no there is no response.
Before studying an AI problem and trying to solve it, the following have to be considered:
- Assumption to be used in solving the problem
- Techniques to be used in solving the problem
- The level of detail at with we are trying to model human intelligence
- How to know when we have succeeded in building an intelligent program.

Knowledge Point of You only ----→

Will Artificial Intelligence Applications Rules Future Information Technology.?

Yes.AI Applications are the talk of IT industry today. Pattern Recognition and Image Processing, Expert systems(Knowledge based Computer Systems) are the major concern of AI research.
The computers of today are knowledge Information processing systems. Expert systems in turn, embody modules of organized knowledge about specific areas of Human Expertise. They also support sophisticated problem- solving and inference functions, providing users with a source of intelligent advice on some specialized topic. Expert systems also provide human oriented I/O in the form of natural Languages, speech, and picture images. For example an Expert System for Medical Diagnosis could operate in the way analogous to the way a Physician, a surgeon, and a patient interact and use their knowledge to make a diagnosis.
Symbol manipulation: In Expert systems(Knowledge based Computer Systems), ”Knowledge” is often represented in terms of IF… THEN rules of the form:
IF Codition.1 and
Condition.2 and
_____
_____
Condition n
THEN implication (with significance)
If all conditions are true, then the implication is true, with an associated logical significance factor. While a set of rules is searched, an overall significance factor is manipulated, and when this significance becomes unacceptably low the search is abounded and a view set of rules is searched.
This structure of expert systems is most closely matched by the structure of logical programming (its computational model). In a logic programming language such as LISP & PROLOG. Prolog statements are relations of a restricted form called ”Clauses”’ and the execution of such program is a suitably controlled logic deduction from the Clauses forming the program. A Clause is a Well formed Formula consisting of Conjunction and Disjunction of Literals. The following logic program for family three Conditions of four Clauses.

Father (Bill, John)
Father (John, Tom)
Grandfather (X,Z) :- father (X,Y) ,mother (Y,Z).
Grandfather (X,Z) :- father (X,Y) ,father (Y,Z).
The first two clauses define that Bill is the father of John, second two clauses use the variables X, Y and Z to represent (express) the rule that if X is the grandfather of Z, if X is the father of Y and Y is either the mother or father of Z . Such a program can be asked a range of questions- from “ is John, the father of Tom?” [Father (John, Tom)?] To “ Is there any A who is the grandfather of C?”[Grandfather (A, C)?] .
The possible operation of computer based on logic is illustrated in the following using the family tree program. Execution of , for example “Grandfather (Bill,R)?”Will match each “Grandfather ( ) “ Clause.
Grandfather (X=Bill, Z=R) :- father (Bill,Y),mother (Y,R).
Grandfather (X=Bill, Z=R) :- father (Bill,Y),father (Y,R).

Both clauses will attempt in parallel to satisfy their Goals, such a concept is called OR – Parallelism. The first clause will fail being unable to satisfy its goal, search will continues to the second clause i.e., called OR – Parallelism.
The first clause will fail being unable to satisfy the "Mother( )" goal form the program. The second goal has "Father( )" , "Mother( )" , which is attempt to solve in parallel, such a concept is called AND parallelism. The later concept involves Pattern Matching methods and substitution to satisfy both the individual goals.
Grandfather (X=Bill, Z=R) : - father (Bill,Y), father (Y,R).
:-father(Bill,Y=John), father (Y=Bill,R=John).
And the Overall Consistency
:-father(Bill,Y=John),father (Y=John,R=Tom).
Computers Organization supporting Expert Systems is a highly micro programmed(Control Flow Based). PROLOG machines analogous to current Lisp machines although we can expect a number of such designs in the near feature. PROLOG machines are not TRUE Logic Machines. Just as LISP Machines are not considered reduction machines liked by a Common logic Machine language and architecture.
Future Potential:- Further Developments in Future in the area of AI Research will be in hopeful manner.

Fifth Generation Project:-

Form the basis of what is called Intelligent Consumer Electronics. Further developments of this type of computer is motivated by the fact that these electronics will be the major money earning industry.

Conclusion:-
If AI Applications from Fifth Generation Project are successfully implemented the above said Logic programs through Perceptual activities i.e. a day will come very soon to act the Computer as Human Brain, ie., what we call Intelligent Computer.

Topic-4-History of Artificial Intelligence

1. The gestation of AI (1943-1955)

- First work on AI
  - ✓ Warren mcculloch and walter pitts
  - ✓ Based on 3 sources
    - i. Knowledge of basic psychology and functions of neurons in brain
    - ii. Formal analysis of propositional logic
    - iii. Theory of computation
  - ✓ Model of artificial neurons
    - Each neuron – ON or OFF
    - Response to stimulation of neighbouring neurons
  - ✓ Any computable function could be computed with some network of connected neurons
  - ✓ Hebbian learning
    - Modifying connection strengths between neurons
  - ✓ First neural network computer in 1951
  - ✓ Alan turing articulated the complete vision of AI
    - computing machinery and intelligence

2.The birth of AI (1956)

- Research on automata theory, neural nets, study of intelligence
- Reasoning program
- Program to prove theorem
- MIT, CMU, Stanford, IBM

- Artificial intelligence (Computational rationality)
- Duplicating human creativity, language

3. Early enthusiasm, great expectations (1952-1969)

- AI – success in a limited way
- Limited computers, programming tools
  - Everything was astonishing
- General problem solver
  - -imitate human problem solving
  - -'think like human' approach
- Physical symbol system
  - -general intelligent action
- High-level language –LISP (2nd oldest high-level language)
- Micro-world – analogy diagrams
- Computer vision, Constraint-propagation network, learning theory, NLP
- Neural networks

4. A dose of reality (1966-1973)

- ✓ AI researcher's statement
- ✓ It is not my aim to surprise or shock you- but the simplest way I can summarize is to say that there are now in the world machines that think, that learn and create.
- ✓ Moreover their ability to do these things is going to increase rapidly until – in a visible feature- the range of problems they can handle will be coextensive with the range to which the human mind has been applied.
- ✓ Computer chess champion
- ✓ Mathematical theorem proving
- ✓ Machine translation\machine evolution
- ✓ -(genetic algorithms – series of small mutations to the machine code program)

5. Knowledge based systems

- General purpose search mechanisms (weak methods)
- Domain specific knowledge
- DENDRAL
  - Solves the problem of inferring molecular structure from the information
  - Successful knowledge intensive system
- Expert systems
  - -medical diagnosis
  - MYCIN – to diagnose blood infections
  - Certainty factors
- Domain knowledge is essential to understand natural language
- Growth of applications to real-world problems
  - -knowledge representation schemes
  - -reasoning language (PROLOG)
  - -frames (assembling facts about particular object)

6. AI becomes an industry (1980 - present)→ First commercial expert systems –R1

7. Neural Networks (1986 to present)

- ✓ Statistical mechanisms to analyse the storage and optimization properties of networks
- ✓ Parallel distributed processing
- ✓ Connectionist models

8. AI becomes a science (1987 to present)

- Internet and shared repositories
- Speech recognition (hidden markov models)
- Data mining
- Bayesian network

9. The emergence of intelligent agents (1995 to present)

- Intelligent agents in internet
  - Search engines. Recommender systems
  - Sonar systems
  - Speech recognition

Topic-5 What is The state of the art???

1. Autonomous planning and scheduling
   -scheduling of operations for a spacecraft
   -plans→ detecting, diagnosing and recovering from problems
2. Game Playing
   -IBM's Deep Blue (Computer program to defeat the world chess champion)
3. Autonomous control
   -computer vision system (to steer a car in a lane)
   - computer controlled mini-van (navigated across US, 2850 miles)
4. Diagnosis
   -medical diagnosis programs (explanation for the diagnosis)
   -machine points out major factors influencing its decision and explains the subtle interaction of several of the symptoms in this case.

Topic-6 Applications of AI

Applications of Artificial Intelligence:-

1.Problem Solving

2.Game Playing

3.Theorem Proving

4.Natural Language Processing & Understanding

5.Perception General

- **Speech Reorganization**
- **Pattern Reorganization**

6.Image Processing

7.Expert System

8.Computer Vision

9.Robotics

10.Intelligent Computer Assisted Instruction

11.Automatic programming

12.Planning & Decision Support systems

13.Engineering Design & Comical Analysis

14. Neural Architecture.

15. Heuristic Classification.

1 Problem Solving:-

This is the first application area of AI research., the objective of this particular area of research is how to implement the procedures on AI systems to solve the problems like Human Beings.

2 :- Game Playing:-

Much of early research in state space search was done using common board games such as checkers, chess and 8 puzzle. Most games are played using a well defined set of rules. This makes it easy to generate the search space and frees the researcher from many of the ambiguities and complexities inherent in less structured problems. The board Configurations used in playing these games are easily represented in computer, requiring none of complex formalisms. For solving large and complex AI problems it requires lots of techniques like Heuristics. We commonly used the term intelligence seems to reside in the heuristics used by Human beings to solve the problems.

3 :- Theorem Proving:-

Theorem proving is another application area of AI research., ie. To prove Boolean Algebra theorems as a humans we first try to prove Lemma., i.e it tell us whether the Theorem is having feasible solution or not. If the theorem having feasible solution we will try to prove it otherwise discard it., In the same way whether the AI system will react to prove Lemma before trying to attempting to prove a theorem., is the focus of this application area of research.

4 Natural Langauge understading:-

The main goal of this problem is we can ask the question to the computer in our mother tongue the computer can receive that particular language and the system gave the response with in the same language. The effective use of a Computer has involved the use off a Programming Language of a set of Commands that we must use

to Communicate with the Computer. The goal of natural language processing is to enable people and language such as English, rather than in a computer language.

It can be divided in to Two sub fields.

Natural Language Understanding : Which investigates methods of allowing the Computer to improve instructions given in ordinary English so that Computers can understand people more easily.

Natural Language Generation : This aims to have Computers produce ordinary English language so that people an understand Computers more easily.

5. Perception:-

The process of perception is usually involves that the set of operations i.e. Touching , Smelling Listening , Tasting , and Eating. These Perceptual activities incorporation into Intelligent Computer System is concerned with the areas of Natural language Understanding & Processing and Computer Vision mainly. The are two major Challenges in the application area of Perception.

1. Speech Reorganization

2. Pattern Reorganization

¨Speech Reorganization:-
The main goal of this problem is how the Computer System can recognize our Speeches. (Next process is to understand those Speeches and process them i.e. Encoding & Decoding i.e producing the result in the same language.) Its one is very difficult; Speech Reorganization can be described in two ways.

1. Discrete Speech Reorganization

Means People can interact with the Computer in their mother tongue. In such interaction whether they can insert time gap in between the two words or two sentences (In this type of Speech Reorganization the computer takes some time for searching the database).

2. Continues Speech Reorganization

Means when we interact with the computer in our mother tongue we can not insert the time gap in between the two words or sentences , i.e. we can talk continuously with the Computer (For this purpose we can increase speed of the computer).

¨Pattern Reorganization: -

this the computer can identify the real world objects with the help of “Camera”. Its one is also very difficult , because

- To identify the regular shape objects, we can see that object from any angle; we can imagine the actual shape of the object (means to picturise which part is light fallen) through this we can identify the total structure of that particular object.

-To identify the irregular shape things, we can see that particular thing from any angle; through this we cannot imagine the actual structure. With help of that we can attach the Camera to the computer and picturise certain part of the light fallen image with the help of that whether the AI system can recognize the actual structure of the image or not? It is some what difficult compare to the regular shape things, till now the research is going on. This is related the application area of Computer Vision.

A Pattern is a quantitative or structured description of an object or some other entity of interest of an Image. Pattern is found an arrangement of descriptors. Pattern recognition is the research area that studies the operation and design of systems that recognize patterns in data. It encloses the discriminate analysis, feature extraction, error estimation, cluster analysis, and parsing (sometimes called syntactical pattern recognition). Important application areas are image analysis, character recognition, speech recognition and analysis, man and machine diagnostics, person identification and industrial inspection.

Closely Related Areas Pattern Recognition

Artificial Intelligence

Expert systems and machine learning

Neural Networks

Computer Vision

Cognition

Perception

Image Processing

6.Image Processing:

-

Where as in pattern reorganization we can catch the image of real world things with the help of Camera. The goal of Image Processing is to identify the relations between the parts of image.

It is a simple task to attach a Camera to a computer so that the computer can receive visual images. People generally use Vision as their primary means of sensing their environment. We generally see more than we here. i.e. how can we provide such perceptual facilities touch, smell, taste, listen, and eat to the AI System. The goal of Computer Vision research is to give computers this powerful facility for understanding their surroundings. Currently, one of the primary uses of Computer Vision is in the area of Robotics.

Ex: - We can take a Satellite image to identify the roots and forests; we can make digitize all the image and place on the disk. With the help of particular scale to convert the image in to dots form, later we can identify that particular image at any time. Its one is time consuming process. With the help of " image processing" how to reduce the time to process an image till now the AI research will be continuously going on.

In Image Processing the process of image recognition can be broken into the following main stages.

· Image capture

· Edge detection

· Segmentation

· Recognition and Analysis.

Image capturing can be performed by a simple Camera, which converts light signals from a scale of electrical signals., i.e., done by human visual system. We obtained these light signals in a set of 0's and 1's. Each pixel takes on one of a number of possible values often from 0 to 255. Color images are broken down in the same

way, but with varying colors instead of gray scales. When a computer receives an image from sensor in form of set of pixels. These pixels are integrated to give the computer an understanding of what it is perceiving.

An image has been obtained, is to determine where the edges are in the image, the very first stage of analysis is called edge detection. Objects in the real world are almost all have solid edges of one kind or another, detecting those images is first step in the process of determining which objects are present in a scene.

Once the edges have been detected, in an image, this information can be used to Segment the image, into homogeneous areas. There are other methods available for segmenting an image, apart from using edge detection, like threshold method. This method involves finding the color of each pixel in an image and considering adjacent pixels to be in the same area as long as their color is similar enough.

A similar method for segmenting images is splitting and merging. Splitting involves taking an area that is not homogeneous and splitting it into two or more smaller areas, each of which is homogeneous. Merging involves taking two areas that are the same as each other, and adjacent to each other and combining them together into a large area. This provides a sophisticated interactive approach to segmenting an image.

Intermediate Level of processing

Low Level Processing High Level Processing

7.Expert system:- Expert means the person who had complete knowledge in particular field, ie is called as an expert. The main aim of this problem is with the help of experts, to load their tricks on to the compute and make available those tricks to the other users. The expert can solve the problems with in the time.

The goal of this problem is how to load the tricks and ideas of an expert on to the computer, till now the research will be going on.

8. Computer Vision:- It is a simple task to attach a camera to a computer so that the computer can receive visual images. People generally use vision as their primary means of sensing their environment. We generally see more than we here, feel, smell, or taste.

The goal of computer vision research is to give computers this powerful facility for understanding their surroundings. Currently, one of the primary uses of computer vision is in the area of Robotics.

9. Robotics:-

A robot is an electro – mechanical device that can be programmed to perfume manual tasks. The robotics industries association formally defines to move a Robot as a " Programmable multi-functional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of variety of tasks".

Not all robotics is considered to be part of AI. A Robot that perform sonly the actions that it is has been pre-programmed to perform is considered to be a "dumb" robot, includes some kind of sensory apparatus, such as a camera , that allows it to respond to changes in its environment , rather than just to follow instructions "mindlessly".

10. Intelligent Computer – Assisted Instruction:-

Computer - Assisted Instruction (CAI) has been used in bringing the power of the computer to bear on the educational process. Now AI methods are being applied to the development of intelligent computerized " Tutors" that shape their teaching techniques to fit the leaning patterns of individual students.

11. Automatic Programming:- Programming is the process of telling the computer exactly what we want to do . the goal of automatic programming is to create special programs that act as intelligent "Tools" to assist programmers and expedite each phase of the programming process. The ultimate aim of automatic programming is a computer system that could develop programs by itself, in response to an in according with the specifications of the program developer.

12. Planning and Decision Support system:- When we have a goal, either we rely on luck and providence to achieve that goal or we design and implement a plan. The realization of a complex goal may require to construction of a formal and detailed plan. Intelligent planning programs are designed to provide active assistance in the planning process and are expected to the particularly helpful to managers with decision making responsibilities.

13. Engineering Design & Camical Analysis:-

Artificial Intelligence applications are playing major role in Engineering Drawings & Camical analysis to design expert drawings and Camical synthesis.

14. Neural Architecture:-

People or more intelligent than Computers,. But AI researchers are trying how make Computers Intelligent. Humans are better at interpreting noisy input, such as recognizing a face in a darkened room from an odd angle. Even where human may not be able to solve some problem, we generally can make a reasonable guess as to its solution. Neural architectures, because they capture knowledge in a large no. of units. Neural architectures are robust because knowledge is distributed somewhat uniformly around the network.

Neural architectures also provide a natural model for parallelism, because each neuron is an independent unit. This showdown searching the data base a massively parallel architecture like the human brain would not suffer from this problem.

15. Heuristic Classification:-

The term Heuristic means to Find & Discover., find the problem and discover the solution. For solving complex AI problems it's requires lots of knowledge and some represented mechanisms in form of Heuristic Search Techniques., i.e refered to known as Heuristic Classification.

AI currently encompasses a huge variety of subfields, ranging from general purpose areas such as learning and perception to such specific tasks as playing chess, proving mathematical theorems, writing poetry and diagnosing diseases.

16 Commonsense reasoning

It is the branch of Artificial intelligence concerned with replicating human thinking. In theory, if the computer is endowed with good Knowledge Representation Database, including a comprehensive common sense database, and is able to process and respond in plain-text English, it will have the ability to process and reason with English texts. The task of Common Sense Knowledge is probably the least studied area, though it is included in many ways in knowledge representation task. There are two issues with this ,one is how to represent the knowledge gathered in a computer processible, and human accessible way. The second task is actually collecting the Common Sense knowledge. There are a couple of different groups who are doing this now. Knowledge Gathering is usually done for expert systems and is limited in its breadth to a limited domain. The two common sense projects are Open Mind Common Sense and Cycorp. To investigate this sort of problems General Problem Solver was developed.

Topic-7 The Birth and Development of Present day AI Research.!

While **Alan Turning** is generally recognized as the 'father' of Artificial Intelligence. Many of his contemporaries were also trying to understand the similarities between mind and machines. The early contribution to his area came mostly from, the scientist of the united states and of Great Britan . Warren McCullots in 1953 proposed that a network of neurons or a natural net in the brain worked in a manner similar to that of the hypothetical turning machine. The idea of considering the brain as a computer was thus born in 1937, Cludeshanon used Boolean algebra to describe the operation of electrical switching circuits. This idea was later used to develop the binary system of information storage used in the digital computers. Shanon is also one of the first scientist to consider the possibility of using computers to play chess. In particular he pointed out that having a computer consider every possible combination of moves was not a practical strategy for chess playing since, even at the rate of evaluation of one million moves per second.

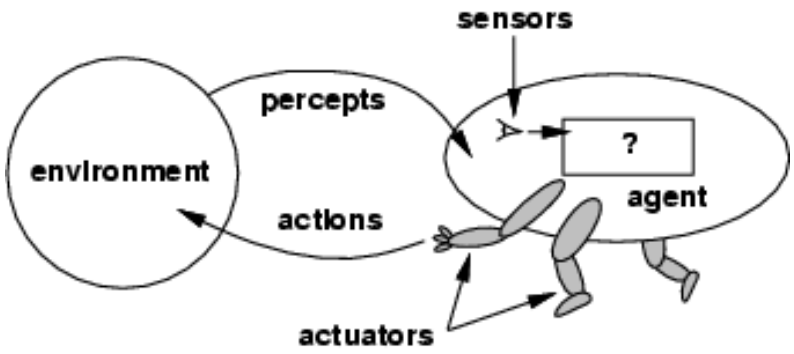
How ever, real AI research programme can be said to have started in 1956 when John McCarthy , one of the organizers of the Dratmouch Conference, suggested the name ' ARTIFICIAL INTELLIGENCE' for the new branch of computer science that took shape during the conference.The conference witnessed participation of scientists from widely varying fields such as neurology mathematics, psychology, cognition, behavioural science and Engineering.

A part from the United States, AI research is underway in many countries like Great Britan,France and Japan has launched one of the worlds largest AI-Project called the Fifth Generation Project a ten year 450 Million Dollar AI research project. In India also AI research is underway in institution like IISC and IIT , Kanpur.

Topic-8 What is Intelligent Agents??

Agent

- An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators
- Human agent: eyes, ears, and other organs for sensors; hands, legs, mouth, and other body parts for actuators
- Robotic agent: cameras and infrared range finders for sensors; various motors for actuators
- Scooter: touch and rotation sensors; wheels

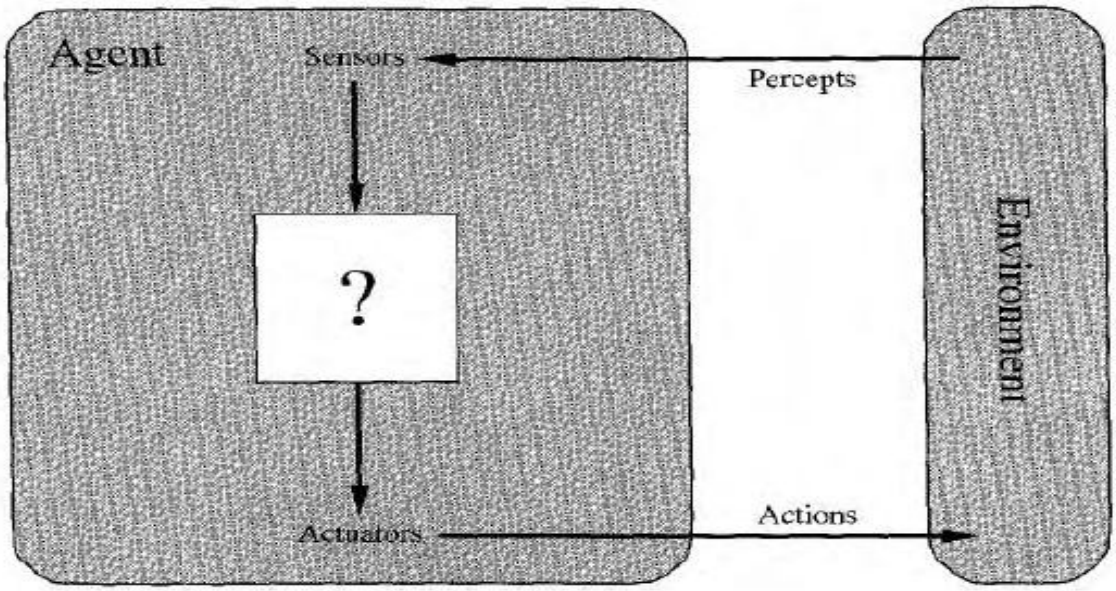


- The agent function maps from percept histories to actions:

  [*f*: P* → A]
- The agent program runs on the physical architecture to produce *f*
- agent = architecture + program

1.Agents and Environments

Agent → perceiving its environment through sensors and acting upon that environment through actuators



- Human agent
  - eyes, ears and other organs for sensors
  - legs, mouth and other body parts for actuators
- Robotic agent
  - Cameras and infra-red range finders for sensors
  - Various motors for actuators
  - Software agent

  -keystrokes, file contents, network packets as sensory inputs

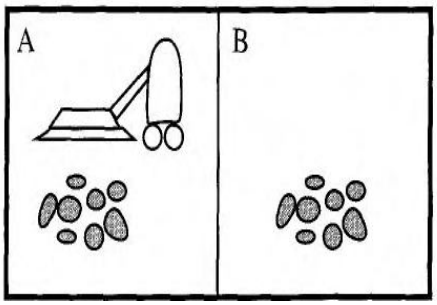
  - display screen, writing files, sending network packets
- percept – agent's perceptual input at any given instant
- Percept sequence – complete history of everything the agent ever perceived
-

Agent function – maps any given percept sequence to an action

- tabulating all agent function (all possible percept sequence)
- external characterization
- abstract mathematical description

- Agent program
  - internal characterization
  - implementation

1. Vacuum cleaner world



- Percepts: location and contents, e.g., [A,Dirty]
- Actions: *Left, Right, Suck, NoOp*

Tabulation of agent function

Percept sequence	Action
[A, *Clean*]	*Right*
[A, *Dirty*]	Suck
[*B*,*Clean*]	*Left*
[*B*,*Dirty*]	Suck

2. Good Behaviour : Concept of Rationality

- Rational Agent
  - doing right thing
  -every entry in the agent function table is correct
  - right action causes the agent to be more successful
- Performance measures
  - embodies the criterion for success of an agent's behaviour
  - not one fixed measure suits for all the agents
  -vacuum cleaner (amount of dirt cleaned up) amount of time taken, amount of electricity consumed, amount of noise generated, etc.

- 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

- Rationality
  - **It depends on 4 things**
  - performance measure
  - Prior knowledge of environment
  - Actions
  - Percept sequence

- **Definition of rational agent**

  -for each possible percept sequence, an agent should select an action that maximizes its performance measure

  - vacuum cleaner

a) Performance measure – awarding points
b) Prior knowledge – geography of environment
c) Actions – left, right, suck, NoOp
d) Percept sequence – perceiving dirt locations

- **omniscience, learning, autonomy**
  - omniscient agent knows the actual outcome of its actions and can act accordingly
  - information gathering
  -exploration
  - learning – to learn as much as possible from what it perceives
  -autonomy – agent should learn what it should compensate for partial or incorrect knowledge

The Nature of Environments

- **Task environments**
- An agent operates within some task environment, not in a blank world.
- This environment includes:
- what the agent is trying to do
- what resources it has to do it
- The nature of the environment affects how we design an appropriate agent.
    - Problems to which the rational agents are the solutions
    - Specifying Task Environments
        - PEAS Description
            - Performance Measure→ How do we assess whether we are doing the right thing?
            - Environment-→ What is the world we are in?
            - Actuators→ How do we affect the world we are in?
            - Sensors→ How do we perceive the world we are in?
- Consider, e.g., the task of designing an automated taxi driver:
    - Performance measure: Safe, fast, legal, comfortable trip, maximize profits
    - Environment: Roads, other traffic, pedestrians, customers
    - Actuators: Steering wheel, accelerator, brake, signal, horn
    - Sensors: Cameras, sonar, speedometer, GPS, odometer, engine sensors, keyboard

Automated Taxi Driver

Agent Type	Performance Measure	Environment	Actuators	Sensors
Taxi driver	Safe: fast, legal, comfortable trip, maximize profits	Roads, other traffic, pedestrians, customers	Steering, accelerator, brake, signal, horn, display	Cameras, sonar, speedometer, GPS, odometer, accelerometer, engine sensors, keyboard

Agent Type	Performance Measure	Environment	Actuators	Sensors
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
Satellite image analysis system	Correct image categorization	Downlink from orbiting satellite	Display categorization of scene	Color pixel arrays
Part-picking robot	Percentage of parts in correct bins	Conveyor belt with parts; bins	Jointed arm and hand	Camera, joint angle sensors
Refinery controller	Maximize purity, yield, safety	Refinery, operators	Valves, pumps, heaters, displays	Temperature, pressure, chemical sensors
Interactive English tutor	Maximize student's score on test	Set of students, testing agency	Display exercises, suggestions, corrections	Keyboard entry

Properties of Task Environments (Types)

- Environments have characteristics which affect the design of an agent
  - Fully vs partially observable
  - Single agent vs multi-agent
  - Deterministic vs stochastic
  - Episodic vs sequential
  - Static vs dynamic
  - Discrete vs continuous
  - Known vs unknown
  -

- Fully observable vs. partially observable: An agent's sensors give it access to the complete state of the environment at each point in time.
- Deterministic vs. stochastic: The next state of the environment is completely determined by the current state and the action executed by the agent.
- Episodic vs. sequential: The agent's experience is divided into atomic "episodes" consisting of perceiving and then performing a single action), and the choice of action in each episode depends only on the episode itself.
- Static vs. dynamic: The environment is unchanged while an agent is deliberating.
- Discrete vs. continuous: A limited number of distinct, clearly defined percepts and actions.
- Single agent vs. multiagent: An agent operating by itself in an environment.
- Known vs unknown: Outcomes of actions are known beforehand

1. Fully observable vs partially observable
   - Sensor gives access to complete state of the environment at each point in time
   - Effectively fully observable
     - sensors detect all aspects that are relevant to the choice of action
   - need not maintain any internal state
   - Parts of the data about the environment is missing due to noisy and inaccurate sensors
     - Vacuum cleaner with only a local sensor (can't know whether other squares have dirt or not)
     - Automated taxi driver (can't know about other drivers)

2. Deterministic vs Stochastic

- Next state is determined by current state and action
  -Otherwise stochastic

- Automated taxi driver
  -- stochastic
  -- Because no one can predict the traffic
- Vacuum world – deterministic

3. **Episodic vs Sequential**

- dividing agent's experiences into atomic episodes
- Each episode has perception and action
- Choice of action
  - Depends on that episode itself
  - doesn't depend on previous episodes

  Ex: for episodic - agent to spot defective parts
  for sequential – chess, taxi-driving

	Crossword puzzle	Taxi driving
Fully observable	Yes	No
Deterministic	Deterministic	Stochastic
Episodic	Sequential	Sequential
Static	Static	Dynamic
Discrete	Discrete	Continuous
Single agent	Single	Multi

- The simplest environment is fully observable, deterministic, episodic, static, discrete and single-agent.
- The real world is (of course) partially observable, stochastic, sequential, dynamic, continuous, multi-agent

4. Static vs Dynamic

- dynamic – change in environment
  - continuously to think/ decide what it wants to do
  - Ex: taxi driving
- Semi dynamic – environment does not change with time but change with agent's performance
- Static – agent does not need to keep looking at the world

5.Discrete vs Continuous

- State of the environment,
  Handling of time,
  Percepts and actions of the agents

Ex: chess – discrete state environment
-- discrete set of percepts and actions

taxi driving – continuous state
- continuous in time
- taxi driving actions are also continuous

6. Single agent vs multi-agent

- Single agent – cross-word puzzle solving agent
- Two agent – agents playing chess
- Chess – competitive environment
- Taxi driving – partially competitive & partially co-operative

The Structure of Agents

Agent Program – implements the agent function, mapping percepts to action

Agent=architecture+program

ex:-program – walk

architecture – legs

PC, Robotic car with on-board computers, cameras and other sensors

Agent programs

-takes just current percept from the environment

Table driven agent

```
function TABLE-DRIVEN-AGENT(percept) returns an action
  static: percepts, a sequence, initially empty
          table, a table of actions, indexed by percept sequences, initially fully specified

  append percept to the end of percepts
  action ← LOOKUP(percepts, table)
  return action
```

Reason for the failure of table driven agent

- ✓ storage space
- ✓ table creation takes much time

- ✓ Cannot learn all entries
- ✓ No guidance to the designer to fill the table

-automated taxi

visual input from single camera takes 27 Mbps

$10^{250000000000}$ percepts

-chess - 10^{150} entries

- To write agent programs with little code but with high rational behaviour

1. SIMPLE REFLEX AGENTS:

- Agents select the actions based on the current percept

Ex: vacuum agent

function REFLEX-VACUUM-AGENT([*location*,*status*]) **returns** an action

if *status* = *Dirty* **then return** *Suck*
else if *location* = *A* **then return** *Right*
else if *location* = B **then return** Left

Condition-Action Rule

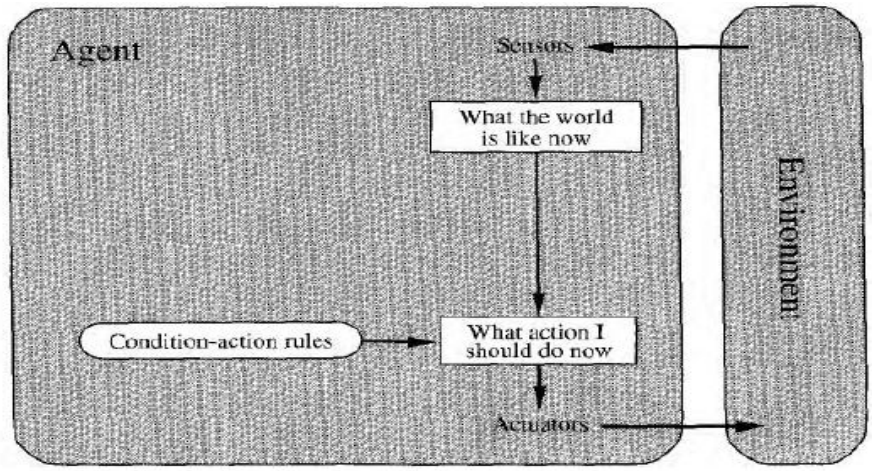
ex: if car in front is braking then initiate braking

-learned responses

- innate reflexes

Schematic diagram of simple reflex agent

- ✓ Observe the world, choose an action, implement action, done.
- ✓ Problems if environment is not fully-observable.
- ✓ Depending on performance metric, may be inefficient.



Agent program

```
function SIMPLE-REFLEX-AGENT(percept) returns an action
  static: rules, a set of condition–action rules

  state ← INTERPRET-INPUT(percept)
  rule ← RULE-MATCH(state, rules)
  action ← RULE-ACTION[rule]
  return action
```

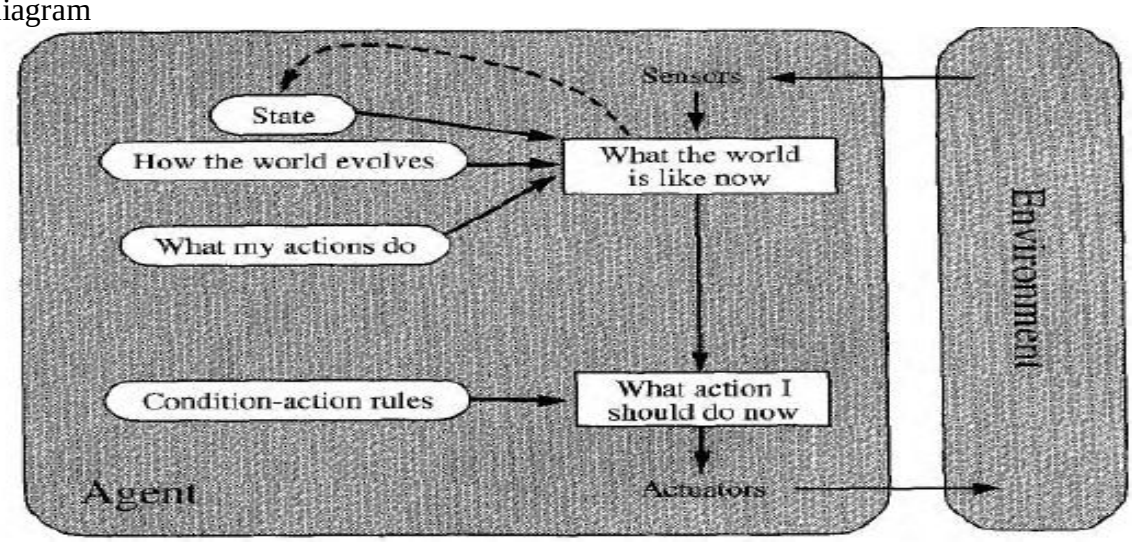
-
- INTERPRET-INPUT→ generates abstracted description of current state
- RULE-MATCH → returns the rule that matches with the current state

- Very limited intelligence (lack of full observability)
  -correct decision can be made only if the environment is fully observable
  -Ex: if automated taxi driver is a simple reflex agent
  → behind a car, ti would either brake continuously and unnecessarily or never brake at all
  -if vacuum cleaner is a simple reflex agent
  → it would have only dirt sensor and not the location sensor, so only 2 percepts dirty and clean. So it can't move left or right.

2.Model based Reflex Agents

- Suppose moving has a cost?
- If a square stays clean once it is clean, then this algorithm will be *extremely* inefficient.
- A very simple improvement would be
  - Record when we have cleaned a square
  - Don't go back once we have cleaned both.
- We have built a very simple *model*.
- Handles partial observability
- Updating internal state information
  - Information about how the world evolves independently of the agent
  - Information about how the agent's own actions affect the world
  - Model of the world

Schematic diagram



More complex agent with model: a square can get dirty again.

```
Function REFLEX_VACUUM_AGENT_WITH_STATE ([location, status]) returns an action.
    last-cleaned-A and last-cleaned-B initially declared = 100.

Increment last-cleaned-A and last-cleaned-B.

if status == Dirty then return Suck

    if location == A

     then

          set last-cleaned-A to 0

          if last-cleaned-B > 3 then return right else no-op

     else

          set last-cleaned-B to 0

          if last-cleaned-A > 3 then return left else no-op
```

The value we check last-cleaned against could be modified.

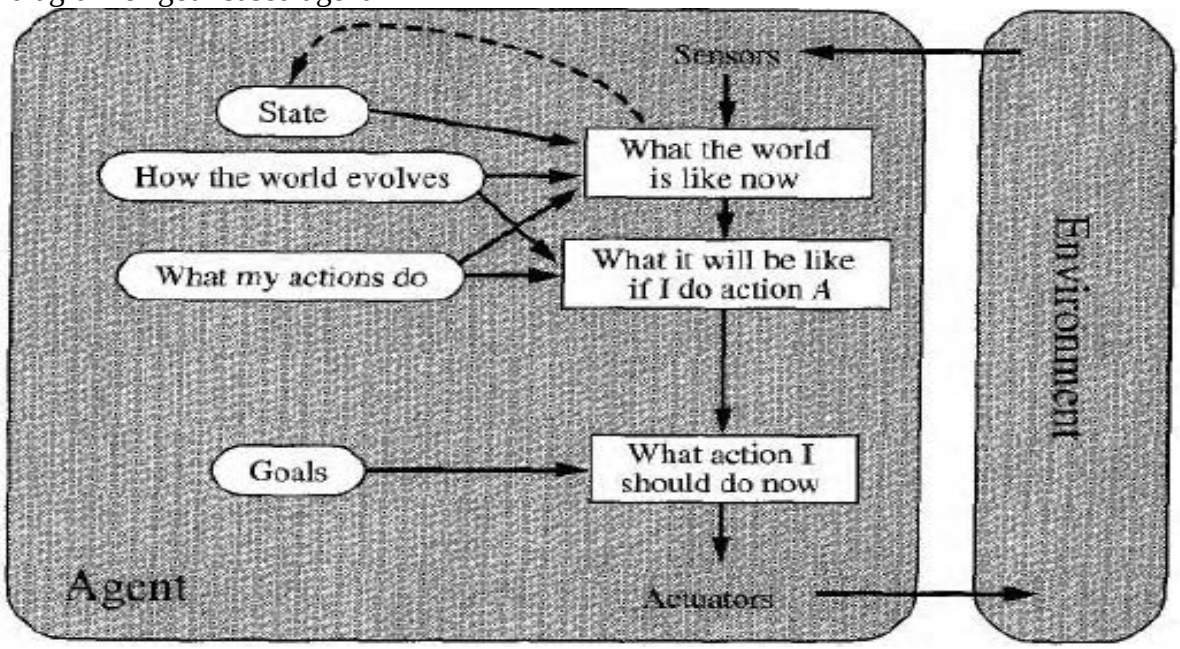
Could track how often we find dirt to compute value

Update State → responsible for creating new internal state information

3. Goal based agents

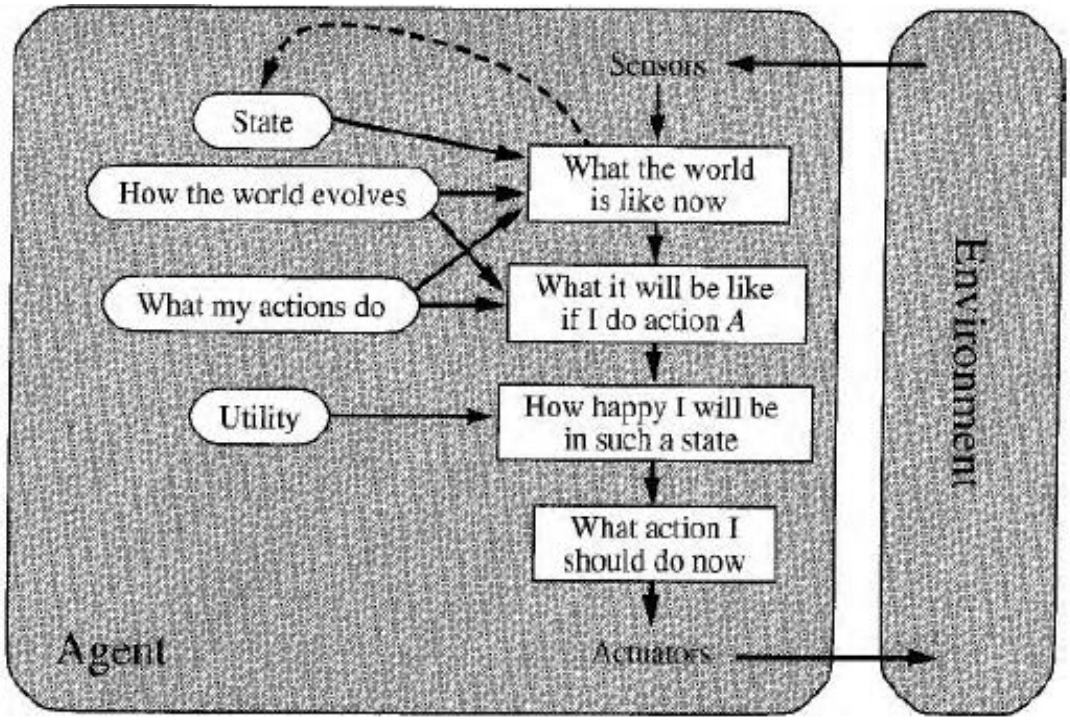
- Agent has some information about desirable situations
- Needed when a single action cannot reach desired outcome
- Therefore performance measure needs to take into account "the future".
- Typical model for search and planning.
- Current state information only is not enough
- Goal information

Schematic diagram of goal based agent



4. Utility based agent

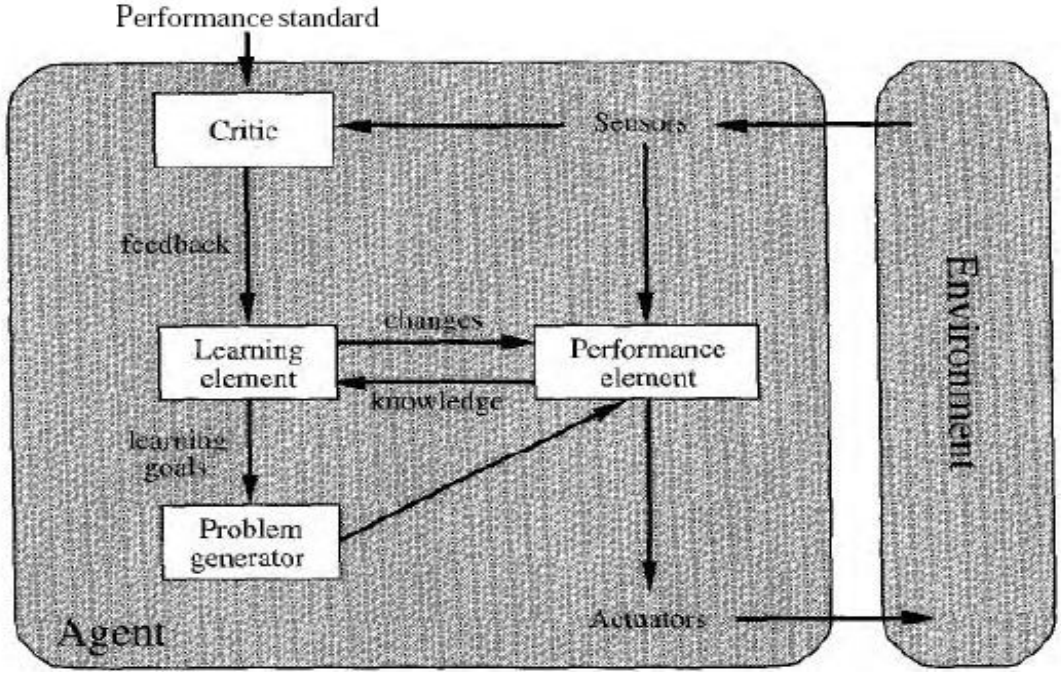
- Possibly more than one goal, or more than one way to reach it
- Some are better, more desirable than others
- There is a utility function which captures this notion of "better".
- Utility function maps a state or sequence of states onto a metric.
- Utility
- Utility function



5. Learning Agents

- All agents have methods for selection actions.
- Learning agents can modify these methods.
- Performance element: any of the previously described agents
- Learning element: makes changes to actions
- Critic: evaluates actions, gives feedback to learning element

Problem generator: suggests actions



Topic-9 Problem Solving with AI

AI has been very well used to solve structured problems. The *well-structured problems* are some of the very commonly faced problems during day-to-day life. These problems yield a right answer or right inference when an appropriate algorithm is applied. While *ill-structured problems* are the problems which do not yield a particular answer. In this case, there is possibility of more than one answer, and even a particular situation decides the correctness of the answer. Interestingly, ill-structured problems represent many of the real-world problems.

Some of the well-structured problems are given below:

1. Solving a quadratic equation to find out the value of X
2. Calculating path of the trajectory when a missile is fired
3. Calculating speed of ball when it reaches to batsman
4. Network flow analysis problems

Some examples of the ill-structured problems are given below:

1. Predicting how to dispose wet waste safely
2. Analysis of theoretical prepositions and adequacy of the same in a particular scenario
3. Identifying the security threats in big social gatherings

Solving ill-structured problems is challenging, since no list of specific and ordered operations or steps exists for them. Further, there is no well-defined criterion to evaluate the correctness of the outcome.

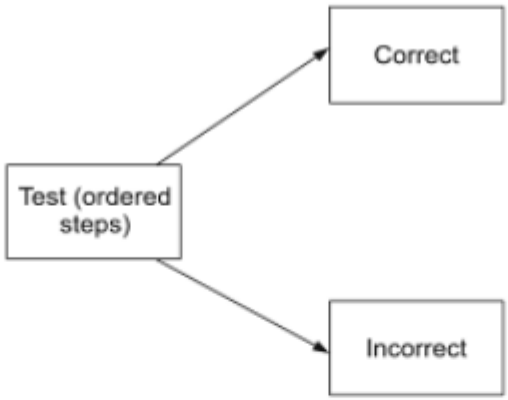


Figure 1.2 A typical well-structured problem analysis.

Figure 1.3 A typical ill-structured problem analysis.

Generally, abstracting the problem is possible in case of structured problems. The similarities and well-defined steps even allow some sort of generalisation in case of well-structured problems. The well-defined steps and well-defined way to measure accuracy allow to head systematically towards the goal state. In case of ill-structured problems, the uniqueness of problems and solution demands high level of problem-specific intelligence

Makes it difficult to generalize.

EXAMPLES: A typical well-structured problem is the tic-tac-toe, shown in Figure 1.4.

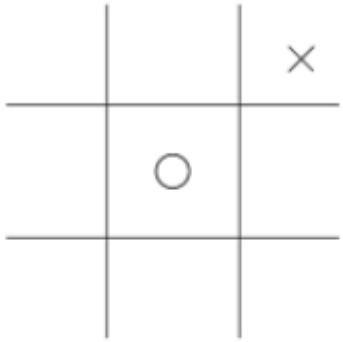


Figure 1.4 Tic-tac-toe.

Here, the final decision will depend on the value associated with all nine positions of tic-tac-toe. The legal values will be player 1 marked, player 2 marked and not marked. In this well-structured problem, solution will try to optimise chances of player 1 while minimising player 2 chances.

On the other hand unstructured problems are difficult to represent and model. There are possibilities of more than one goal states in case of unstructured problems. In most of the cases, exact goal state is not known. For example, systems to improve life expectancy of human being, expanding the business.

Linear problems are the ones which definitely have a solution or there will not be any solution. Speaking with respect to AI problem solving, these problems are the ones that typically fall under the classification category. Whereas, the problems that are not linear have to undergo some transformation for getting solution.

In case of non-linear problems, the relationship between input and output is not linear. Further decisions cannot be separated by simple linear classification function.

1.5 AI MODELS

One important aspect of building AI solutions is modelling the problem. Dunker introduced 'maze hypothesis' as a part of the psychological theory. In this particular hypothesis, the creative and intelligent tasks handled by human beings are modelled like a set of maze of paths from an initial node to a certain or resultant node. Human at any point of time analyses maze; for choices, he could find those which can lead to goal. These choices and maze-based approach can help in solving many multialternative solution problems.

Slowly, it became evident that all problems cannot be solved using maze models or the approach described above. This brought more focus on logic theory machines. Effective application of logic theory machines is found very useful in general problem solving, even this is found very useful for a wide spectrum of problems like chess problem. Chess can be viewed as a controlled environment in which computer is given a situation and a goal.

Figure 1.5 depicts the complexity of model building with reference to data and knowledge mapping.

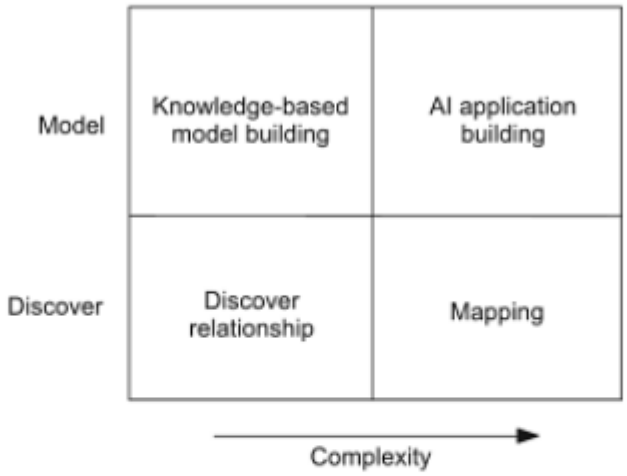


Figure 1.5 Model building and complexity.

A typical chess scenario is given in Figure 1.6. This is a much complex scenario than tic-tac-toe, but is still constrained. The chess program provided a sort of background for AI research. Two aspects that could be viewed from chess program were knowledge-based search and knowledge acquisition and representation. Models used for applications like chess programs were not effective for the other applications.

The advent of natural language processing and the need for man-machine dialogue made it more evident that the models used so far had their own limitations. Then, the formal models were proposed to solve AI problems. The requirement of complex problem solving gave birth to dynamic inductive models. Human behaviour and psychological study-based inductive dynamic models for creative problem solving slowly became popular.

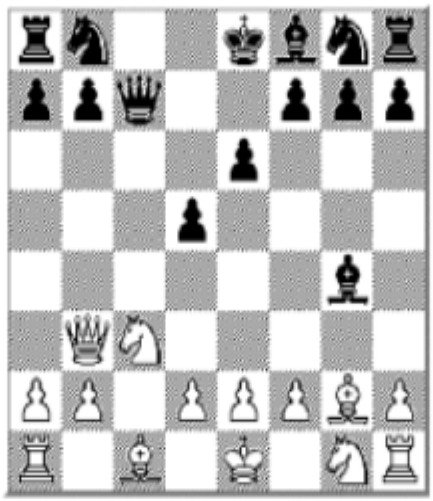


Figure 1.6 Chess: A complex scenario.

Let us have a look at the models.

Semiotic Models

These models are based on sign processes or signification and communication. The process of carrying meaning depends on codes. Semioticians classify signs or sign systems in relation to the problem. This meaning assignment and mapping process depends on the use of codes based on individual sounds or letters that humans use to form words or movements. In computers, these signs are determined for a logical sequence.

Statistical Models

Statistical models refer to representation and formalisation of relationships through statistical techniques. Most of the AI problems can be represented as statistical or pattern matching problems. Various learning models from AI perspective are based on statistics. The historical data is used here in decision-making. Statistical model employs probabilistic approaches and is typically a collection of probability density functions and distribution functions.

1.6 DATA ACQUISITION AND LEARNING ASPECTS IN AI

This section will introduce various AI-related topics on data acquisition and machine learning.

1. ***Knowledge discovery—Data mining and machine learning***: We start with some simple terms, i.e., information and data. Information can be referred to as pattern underlying the data, whereas the data refers to recorded facts. So, we define *data mining* or *knowledge discovery* as the extraction of meaningful information that is previously unknown and can be useful potentially ahead. It is more concerned with data analysis and use of some techniques to identify and recognise the patterns that would yield good predictions. The mining process includes data cleaning, preprocessing, identifying and interpreting the patterns, understanding the application and generating the target data with the consolidated patterns.

Machine learning, as described by Tom Mitchell, is a field concerned with the study of algorithms that will improve its performance with experience. It is all about making machine behave intelligently based on the past experience.

Let us have a look at the relation between knowledge discovery and machine learning. *Knowledge discovery* is about finding understandable knowledge, while *machine learning* is more focussed on improving performance of an agent. Machine learning can be thought of as a broader concept, which has mining playing an implicit part. There is actually a very fuzzy distinction between them.

That is all about the concepts' part, but what about the applications? Data mining is a tool and holds core part in business intelligence (BI). Data mining plays a critical role in case of accurate and complex decision-making. Consider a simple example of a bank which wants to access credit risk of customers. Let us say Ram applies for loan. Should the loan be approved? Data about past credit history, timely payments, security, age, salary are some of the factors that are looked upon. Bank generally develops models using machine learning methods, with the parameters mentioned. The results predict whether Ram would default on loan or not.

2. *Computational learning theory (COLT)*: Currently, a lot of research is done to study and analyse algorithms. In COLT, formal mathematical models are defined. These models help in analyzing the efficiency and complexity in terms of computation, prediction and feasibility of the algorithms. The analysis done provides a framework to take appropriate decisions for building better algorithms that would be effective in terms of data and time.

The computational learning theory finds its importance in the field of machine learning, pattern recognition, statistics and many more. With regard to machine learning, the goal of COLT is to inductively learn the target function. Learning theories help in understanding the explicit relevant aspects of the learner and the environment to classify easy and hard learning problems and in turn guiding the design learning systems. There are two frameworks for analysing the patterns—one is Probably Approximately Correct (PAC) and the other is mistake bound. The former identifies the classes of hypothesis that possibly can/cannot be learnt, whereas the latter tries to learn target function to series of trials.

3. *Neural and evolutionary computation*: A new technique in computation, i.e., neural and evolutionary computation is enabled to speed up the mining of data. Computation techniques that are based on biological properties fall under the category of evolutionary computing. Evolutionary computing is related to the study and use of these properties, consisting of evolutionary algorithms (of which genetic algorithm has been the most popular) that are basically used to solve multidimensional problem. The evolutionary computing finds its applications from the telecom domain to the financial decision-making, with optimisation as the base criterion.

In case of neural computing, the neural behaviour of human beings is stimulated to enable machine to learn. An artificial neural network is formed or configured for some specific application like pattern recognition or classification.

4. *Intelligent agents and multi-agent systems:* Intelligent agents and multi-agent systems (MAS) is a core part of intelligent systems, which allows timely decision-making in complex scenarios. An *agent* in simple terms, is a software program that assists user. An *intelligent agent* is the one which is flexible in terms of its action to get the desired outcome. It is goal-directed, reacts with the environment and acts accordingly. Consider an example of a student, who is pursuing a course in web designing. He uses search engine to get some notes for the subject. An intelligent agent will observe that he accesses the sites, which give him the detailed examples of the topics. So, each time he fires some query, the agent will give up sites that he is likely to refer based on the past experience. After some days, when he refers to the sites with illustrations, then the agent would need to change its behaviour pattern and act accordingly.

The capacity of an intelligent agent is restricted, and is dependent on the knowledge it has, the available resources and the different perspectives. The percept of individual agent is always limited. Complex tasks and decision-making demand combination of more than one percept of different intelligent agents. Hence, in many cases group of intelligent agents are required to solve the problems. This is a scenario of multi-agent system. So, in MAS, every agent's capability and its computation efficiency is exploited so that the overall performance is improved.

5. *Multi-perspective integrated intelligence:* For any problem to solve, each and every individual can have his own perspective. Some information might be present in some perspective, while it could be missing in other perspective, which could be effective in terms of decision-making. Utilising and exploiting this knowledge from different perspectives to build up an intelligent system giving accurate results, builds the Multi-perspective Intelligence (MPI) framework. Consider a scenario, where you want to apply for a job in a renowned company. You tend to seek feedback from some employees. Each will have his own perspective in relation to management, working environment, appraisals and so on. Some friend of yours might not be working, but is acquainted with the company. He would also have a different perspective. Based on this knowledge, possibly you could land upon a decision whether to take up the job or not. Information collected from different perspectives is used for final decision-making. This information collection can be continuous or discrete.

These learning approaches work in association with respect to the application they would be suited for. As said earlier, there is a very fuzzy line of distinction between them. And a good understanding of requirements and domain will result into accurate predictions and decision-making for solving a problem. The topics introduced here are just to make you aware of the type of work done with AI, though we will be discussing most them in detail in further chapters.

**********THE END**********