Unit - I

Introduction, History, Intelligent Systems, Foundations of AI, Sub areas of AI, Applications. Problem Solving – State-Space Search and Control Strategies: Introduction, General Problem Solving, Characteristics of Problem, Exhaustive Searches, Heuristic Search Techniques, Iterative-Deepening A*, Constraint Satisfaction

Topic: AI Introduction:

In today's world, technology is growing very fast, and we are getting in touch with different new technologies day by day. Here, one of the booming technologies of computer science is Artificial Intelligence which is ready to +create a new revolution in the world by making intelligent machines.The Artificial Intelligence is now all around us. It is currently working with a variety of subfields, ranging from general to specific, such as self-driving cars, playing chess, proving theorems, playing music, Painting, etc.

AI is one of the fascinating and universal fields of Computer science which has a great scope in future. AI holds a tendency to cause a machine to work as a human

Artificial Intelligence is composed of two words **Artificial** and **Intelligence**, where Artificial defines *"man-made,"* and intelligence defines *"thinking power"*, hence AI means *"a man-made thinking power."*

So, we can define AI as:

"It is a branch of computer science by which we can create intelligent machines which can behave like a human, think like humans, and able to make decisions."

Artificial Intelligence exists when a machine can have human based skills such as learning, reasoning, and solving problems

With Artificial Intelligence you do not need to preprogram a machine to do some work, despite that you can create a machine with programmed algorithms which can work with own intelligence, and that is the awesomeness of AI.

It is believed that AI is not a new technology, and some people says that as per Greek myth, there were Mechanical men in early days which can work and behave like humans.

Why Artificial Intelligence?

Before Learning about Artificial Intelligence, we should know that what is the importance of AI and why should we learn it. Following are some main reasons to learn about AI:

- With the help of AI, you can create such software or devices which can solve real-world problems very easily and with accuracy such as health issues, marketing, traffic issues, etc.
- With the help of AI, you can create your personal virtual Assistant, such as Cortana, Google Assistant, Siri, etc.
- With the help of AI, you can build such Robots which can work in an environment where survival of humans can be at risk.
- AI opens a path for other new technologies, new devices, and new Opportunities.

Goals of Artificial Intelligence:

Following are the main goals of Artificial Intelligence:

1. Replicate human intelligence
2. Solve Knowledge-intensive tasks
3. An intelligent connection of perception and action

4. Building a machine which can perform tasks that requires human intelligence such as:
    - Proving a theorem
    - Playing chess
    - Plan some surgical operation
    - Driving a car in traffic
5. Creating some system which can exhibit intelligent behavior, learn new things by itself, demonstrate, explain, and can advise to its user.

What Comprises to Artificial Intelligence?

Artificial Intelligence is not just a part of computer science even it's so vast and requires lots of other factors which can contribute to it. To create the AI first we should know that how intelligence is composed, so the Intelligence is an intangible part of our brain which is a combination of **Reasoning, learning, problem-solving perception, language understanding, etc**.

To achieve the above factors for a machine or software Artificial Intelligence requires the following discipline:

- Mathematics
- Biology
- Psychology
- Sociology
- Computer Science
- Neurons Study
- Statistics

Advantages of Artificial Intelligence:

Following are some main advantages of Artificial Intelligence:

- **High Accuracy with less errors:** AI machines or systems are prone to less errors and high accuracy as it takes decisions as per pre-experience or information.
- **High-Speed:** AI systems can be of very high-speed and fast-decision making, because of that AI systems can beat a chess champion in the Chess game.
- **High reliability:** AI machines are highly reliable and can perform the same action multiple times with high accuracy.
- **Useful for risky areas:** AI machines can be helpful in situations such as defusing a bomb, exploring the ocean floor, where to employ a human can be risky.

- **Digital Assistant:** AI can be very useful to provide digital assistant to the users such as AI technology is currently used by various E-commerce websites to show the products as per customer requirement.
- **Useful as a public utility:** AI can be very useful for public utilities such as a self-driving car which can make our journey safer and hassle-free, facial recognition for security purpose, Natural language processing to communicate with the human in human-language, etc.

Disadvantages of Artificial Intelligence:

Every technology has some disadvantages, and thesame goes for Artificial intelligence. Being so advantageous technology still, it has some disadvantages which we need to keep in our mind while creating an AI system. Following are the disadvantages of AI:

- **High Cost:** The hardware and software requirement of AI is very costly as it requires lots of maintenance to meet current world requirements.
- **Can't think out of the box:** Even we are making smarter machines with AI, but still they cannot work out of the box, as the robot will only do that work for which they are trained, or programmed.
- **No feelings and emotions:** AI machines can be an outstanding performer, but still it does not have the feeling so it cannot make any kind of emotional attachment with human, and may sometime be harmful for users if the proper care is not taken.
- **Increase dependency on machines:** With the increment of technology, people are getting more dependent on devices and hence they are losing their mental capabilities.

- **No Original Creativity:** As humans are so creative and can imagine some new ideas but still AI machines cannot beat this power of human intelligence and cannot be creative and imaginative

Topic:History of Artificial Intelligence:

Artificial Intelligence is not a new word and not a new technology for researchers. This technology is much older than you would imagine.

Maturation of Artificial Intelligence (1943-1952)

- **Year 1943:** The first work which is now recognized as AI was done by Warren McCulloch and Walter pits in 1943. They proposed a model of **artificial neurons**.
- **Year 1949:** Donald Hebb demonstrated an updating rule for modifying the connection strength between neurons. His rule is now called **Hebbian learning**.
- **Year 1950:** The Alan Turing who was an English mathematician and pioneered Machine learning in 1950. Alan Turing publishes **"Computing Machinery and Intelligence"** in which he proposed a test. The test can check the machine's ability to exhibit intelligent behavior equivalent to human intelligence, called a **Turing test**.

The birth of Artificial Intelligence (1952-1956)

- **Year 1955:** An Allen Newell and Herbert A. Simon created the "first artificial intelligence program"Which was named as **"Logic Theorist"**. This program had proved 38 of 52 Mathematics theorems, and find new and more elegant proofs for some theorems.
- **Year 1956:** The word "Artificial Intelligence" first adopted by American Computer scientist John McCarthy at the Dartmouth Conference. For the first time, AI coined as an academic field.

At that time high-level computer languages such as FORTRAN, LISP, or COBOL were invented. And the enthusiasm for AI was very high at that time.

The golden years-Early enthusiasm (1956-1974)

- **Year 1966:** The researchers emphasized developing algorithms which can solve mathematical problems. Joseph Weizenbaum created the first chatbot in 1966, which was named as ELIZA.
- **Year 1972:** The first intelligent humanoid robot was built in Japan which was named as WABOT-1.

The first AI winter (1974-1980)

- The duration between years 1974 to 1980 was the first AI winter duration. AI winter refers to the time period where computer scientist dealt with a severe shortage of funding from government for AI researches.
- During AI winters, an interest of publicity on artificial intelligence was decreased.

A boom of AI (1980-1987)

- **Year 1980:** After AI winter duration, AI came back with "Expert System". Expert systems were programmed that emulate the decision-making ability of a human expert.
- In the Year 1980, the first national conference of the American Association of Artificial Intelligence **was held at Stanford University**.

The second AI winter (1987-1993)

- The duration between the years 1987 to 1993 was the second AI Winter duration.

- Again Investors and government stopped in funding for AI research as due to high cost but not efficient result. The expert system such as XCON was very cost effective.

The emergence of intelligent agents (1993-2011)

- **Year 1997:** In the year 1997, IBM Deep Blue beats world chess champion, Gary Kasparov, and became the first computer to beat a world chess champion.
- **Year 2002:** for the first time, AI entered the home in the form of Roomba, a vacuum cleaner.
- **Year 2006:** AI came in the Business world till the year 2006. Companies like Facebook, Twitter, and Netflix also started using AI.

Deep learning, big data and artificial general intelligence (2011-present)

- **Year 2011:** In the year 2011, IBM's Watson won jeopardy, a quiz show, where it had to solve the complex questions as well as riddles. Watson had proved that it could understand natural language and can solve tricky questions quickly.
- **Year 2012:** Google has launched an Android app feature "Google now", which was able to provide information to the user as a prediction.
- **Year 2014:** In the year 2014, Chatbot "Eugene Goostman" won a competition in the infamous "Turing test."

- **Year 2018:** The "Project Debater" from IBM debated on complex topics with two master debaters and also performed extremely well.
- Google has demonstrated an AI program "Duplex" which was a virtual assistant and which had taken hairdresser appointment on call, and lady on other side didn't notice that she was talking with the machine.

Topic:Intelligent system:

intelligent systems can also include sophisticated AI-based software systems, such as chatbots, expert systems and other types of software.

Essentially, an intelligent device is anything that contains a functional, although not usually general-purpose, computer with Internet connectivity. An embedded system may be powerful and capable of complex processing and data analysis, but it is usually specialized for tasks relevant to the host machine.

Intelligent systems exist all around us in point-of-sale (POS) terminals, digital televisions, traffic lights, smart meters, automobiles, digital signage and airplane controls, among a great number of other possibilities. Built-in intelligence is an integral component of the developing internet of things (IoT), in which almost everything imaginable can be provided with unique identifiers and the ability to automatically transfer data over a network without requiring human-to-human or human-to-computer interaction.

Topic:Foundations of AI and sub areas of AI:

AI into five distinct research areas

- **Machine Learning**
- **Expert Systems**
- **Computer Vision**
- **Natural Language Processing**
- **Robotics**

1.Machine Learning:

Machine learning (ML) is the science of **empowering machines to make decisions without human intervention**. This sub-discipline forms the backbone of AI, enabling computers to learn and interpret patterns in images, sounds, and structured data using multidimensional arrays. ML is further subdivided into four types of learning:

- **Supervised learning**: Given an array of features (i.e., week of the year, price, etc.) and a labeled output variable (e.g., sales), predict the best possible estimate of the label variable given some new input array.
- **Unsupervised learning**: Given an array of features (e.g., demographic information, ZIP code, etc.), expose and visualize hidden relationships and anomalies within the array.

- **Semi-supervised**: Given an array of features and a limited quantity of some labeled output variable, predict the best possible estimates for the missing label variables.
- **Reinforcement learning:** Given some objective, train an artificial agent to maximize its utility according to some user-defined utility function.

Machine learning is to thank for many high-profile innovations over the past few years, but it’s more difficult to do correctly than commonly believed.

2. Expert Systems:

An expert system (ES) is an **artificial agent which leverages pre-programmed knowledge to offer advice or make decisions**. An expert system can **take advantage of human insights** discovered through trial and error

- Expert systems are **more predictable** and are **less likely to make extreme errors** when faced with previously-unseen inputs
- Expert systems **have historically been faster and easier to implement**, though ML has become much more accessible in recent years

Google's Nest thermometer

Google's Nest home automation technology is a prime example of an ES at work. Users program their preferences into Nest over time, enabling the system to automatically adjust housing temperature to desired levels and reduce heating expenses. Using ML to predict desired temperatures could lead to wild swings in settings and energy costs, so user-defined logic is critical to stabilizing these predictions.(Another examples :MYCIN,DENDRAL,PXDES,CADET)

3. Computer Vision:

Computer vision (CV) is the **automatic extraction, analysis, and interpretation of images or videos**. CV converts photos and videos into numerical arrays, enabling ML algorithms to draw inferences, make predictions, and even generate new images based on user-defined inputs.

Example of an image being converted to an array:

Potential uses for CV have been studied for decades, but CV has only recently become possible at scale thanks to three innovations:

- **More efficient algorithms:** Deep learning and convolutional neural networks.specifically significantly reduces the memory footprint and computational runtime of CV tasks.

- **Better computing resources**: GPU improvements, distributed architectures (e.g., Spark), and the availability of inexpensive cloud computing resources have made it cheaper than ever to run memory-hungry CV algorithms.
- **Availability of images to train on**: The proliferation of social media platforms, community forums, and digital / mobile cameras have drastically increased the number of publicly-available images that can be used to train CV algorithms.

These three innovations have opened the floodgates for new CV use cases, including self-driving cars and automated retailers (e.g., Amazon Go). As cameras, LIDAR(light detection and ranging), and other spatial sensors become less expensive, we'll soon find ways to alleviate many of our most inefficient processes using CV.

4. Natural Language Processing:

Natural language processing (NLP) is the **automatic extraction, analysis, and generation of human language**. NLP algorithms parse sentences in various ways (e.g., splitting by word, splitting by letter, reading both left-to-right and right-to-left, etc.) to automatically draw inferences about the writer's meaning and intent. NLP's various use cases include:

- Named entity recognition and conference resolution
- Part-of-speech tagging
- Reading comprehension & question answering
- Machine translation
- Text summarization & topic modeling
- Spellcheck & autocomplete

Like CV, NLP has come a long way over the past decade thanks to innovations in deep learning that have made it faster and easier to train ML models on human language. In the past, engineers would spend hours examining, filtering, and transforming text to avoid computational bottlenecks. Today, out-of-the-box solutions like fast.ai's NLP library can crush reading comprehension accuracy records without need for time-intensive preprocessing.

Siri and Alexa are great examples of NLP in action: by listening for “wake words”, these tools allow you to play music, search the Web, create to-do lists, and control popular smart-home products — all while your smartphone stays in your pocket. These virtual assistants will continue to improve over time as they gather data from existing users, unlocking new use cases and integrating with the modern enterprise.

5. Robotics:

Robotics is the **science of designing, constructing, operating, and applying robots** to solve human problems. Robots come in thousands of shapes and sizes, making it difficult to nail down the precise meaning of the term.

Boston Dynamic’s Atlas

The field of robotics research has evolved at breakneck speed over the past decade. Most robots rely on expert systems to accomplish their objective, but the robots of tomorrow will become exponentially more useful by incorporating machine learning, computer vision, and natural language processing into their operating systems.

Topic:AI Applications:

1. AI in E-Commerce:

a) Personalized Shopping

Artificial Intelligence technology is used to create recommendation engines through which you can engage better with your customers. These recommendations are made in accordance with their browsing history, preference, and interests. It helps in improving your relationship with your customers and their loyalty towards your brand.

b) AI-powered Assistants

Virtual shopping assistants and chatbots help improve the user experience while shopping online. Natural Language Processing is used to make the conversation sound as human and personal as possible. Moreover, these assistants can have real-time engagement with your customers. Did you know that on amazon.com, soon, customer service could be handled by chatbots?

c) Fraud Prevention

Credit card frauds and fake reviews are two of the most significant issues that E-Commerce companies deal with. By considering the usage patterns, AI can help reduce the possibility of credit card frauds taking place. Many customers prefer to buy a product or service based on customer reviews. AI can help identify and handle fake reviews.

2. AI in Navigation:

Based on research from MIT, GPS technology can provide users with accurate, timely, and detailed information to improve safety. The technology uses a combination of Convolutional Neural Network and Graph Neural Network, which makes lives easier for users by automatically detecting the number of lanes and road types behind obstructions on the roads. AI is heavily used by Uber and many logistics companies to improve operational efficiency, analyze road traffic, and optimize routes.

3. AI in Robotics:

Robotics is another field where artificial intelligence applications are commonly used. Robots powered by AI use real-time updates to sense obstacles in its path and pre-plan its journey instantly.

It can be used for -

- Carrying goods in hospitals, factories, and warehouses
- Cleaning offices and large equipment
- Inventory management

4. AI in Human Resource

Did you know that companies use intelligent software to ease the hiring process?

Artificial Intelligence helps with blind hiring. Using machine learning software, you can examine applications based on specific parameters. AI drive systems can scan job candidates' profiles, and resumes to provide recruiters an understanding of the talent pool they must choose from.

5. AI in Healthcare:

Artificial Intelligence finds diverse applications in the healthcare sector. AI is used in healthcare to build sophisticated machines that can detect diseases and identify cancer cells. AI can help analyze chronic conditions with lab and other medical data to ensure early diagnosis. AI uses the combination of historical data and medical intelligence for the discovery of new drugs.

6. AI in Agriculture:

Artificial Intelligence is used to identify defects and nutrient deficiencies in the soil. This is done using computer vision, robotics, and machine learning, AI can analyze where weeds are growing. AI bots can help to harvest crops at a higher volume and faster pace than human laborers.

7. AI in Gaming:

Another sector where Artificial Intelligence applications have found prominence is the gaming sector. AI can be used to create smart, human-like NPCs to interact with the players.

It can also be used to predict human behavior using which game design and testing can be improved. The Alien Isolation games released in 2014 uses AI to stalk the player throughout the game. The game uses two Artificial Intelligence systems - 'Director AI' that frequently knows your location and the 'Alien AI,' driven by sensors and behaviors that continuously hunt the player.

8. AI in Automobiles:

Artificial Intelligence is used to build self-driving vehicles. AI can be used along with the vehicle's camera, radar, cloud services, GPS, and control signals to operate the vehicle. AI can improve the in-vehicle experience and provide additional systems like emergency braking, blind-spot monitoring, and driver-assist steering.

9. AI in Social Media:

Instagram

On Instagram, AI considers your likes and the accounts you follow to determine what posts you are shown on your explore tab.

Facebook

Artificial Intelligence is also used along with a tool called DeepText. With this tool, Facebook can understand conversations better. It can be used to translate posts from different languages automatically.

Twitter

AI is used by Twitter for fraud detection, removing propaganda, and hateful content. Twitter also uses AI to recommend tweets that users might enjoy, based on what type of tweets they engage with.

10. AI in Marketing:

Artificial intelligence applications are popular in the marketing domain as well.

- Using AI, marketers can deliver highly targeted and personalized ads with the help of behavioral analysis, pattern recognition, etc. It also helps with retargeting audiences at the right time to ensure better results and reduced feelings of distrust and annoyance.
- AI can help with content marketing in a way that matches the brand's style and voice. It can be used to handle routine tasks like performance, campaign reports, and much more.
- Chatbots powered by AI, Natural Language Processing, Natural Language Generation, and Natural Language Understanding can analyze the user's language and respond in the ways humans do.

- AI can provide users with real-time personalizations based on their behavior and can be used to edit and optimize marketing campaigns to fit a local market's needs.

Topic: Problem Solving – State-Space Search and Control Strategies: Introduction

The **reflex agents** are known as the simplest agents because they directly map states into actions. Unfortunately, these agents fail to operate in an environment where the mapping is too large to store and learn. **Goal-based agent,** on the other hand, considers future actions and the desired outcomes.

Here, we will discuss one type of goal-based agent known as a **problem-solving agent**, which uses atomic representation with no internal states visible to the *problem-solving algorithms*.

Problem-solving agent

The problem-solving agent perfoms precisely by defining problems and its several solutions.

According to psychology, "*a problem-solving refers to a state where we wish to reach to a definite goal from a present state or condition."*

According to computer science, *a problem-solving is a part of artificial intelligence which encompasses a number of techniques such as algorithms, heuristics to solve a problem.*

Therefore, a problem-solving agent is a **goal-driven agent** and focuses on satisfying the goal.

Steps performed by Problem-solving agent

- **Goal Formulation:** It is the first and simplest step in problem-solving. It organizes the steps/sequence required to formulate one goal out of multiple goals as well as

actions to achieve that goal. Goal formulation is based on the current situation and the agent's performance measure (discussed below).

- **Problem Formulation:** It is the most important step of problem-solving which decides what actions should be taken to achieve the formulated goal. There are following five components involved in problem formulation:
- **Initial State:** It is the starting state or initial step of the agent towards its goal.
- **Actions:** It is the description of the possible actions available to the agent.
- **Transition Model:** It describes what each action does.
- **Goal Test:** It determines if the given state is a goal state.
- **Path cost:** It assigns a numeric cost to each path that follows the goal. The problem-solving agent selects a cost function, which reflects its performance measure. Remember, **an optimal solution has the lowest path cost among all the solutions.**

  Note: Initial state, actions, and **transition model** together define the **state-space** of the problem implicitly. State-space of a problem is a set of all states which can be reached from the initial state followed by any sequence of actions. The state-space forms a directed map or graph where nodes are the states, links between the nodes are actions, and the path is a sequence of states connected by the sequence of actions.
- **Search:** It identifies all the best possible sequence of actions to reach the goal state from the current state. It takes a problem as an input and returns solution as its output.
- **Solution:** It finds the best algorithm out of various algorithms, which may be proven as the best optimal solution.
- **Execution:** It executes the best optimal solution from the searching algorithms to reach the goal state from the current state.

  Example Problems

Basically, there are two types of problem approaches:

- **Toy Problem:** It is a concise and exact description of the problem which is used by the researchers to compare the performance of algorithms.
- **Real-world Problem:** It is real-world based problems which require solutions. Unlike a toy problem, it does not depend on descriptions, but we can have a general formulation of the problem.

Some Toy Problems

- **8 Puzzle Problem:** Here, we have a 3×3 matrix with movable tiles numbered from 1 to 8 with a blank space. The tile adjacent to the blank space can slide into that space. The objective is to reach a specified goal state similar to the goal state, as shown in the below figure.
- In the figure, our task is to convert the current state into goal state by sliding digits into the blank space.

In the above figure, our task is to convert the current(Start) state into goal state by sliding digits into the blank space.

The problem formulation is as follows:

- **States:** It describes the location of each numbered tiles and the blank tile.

- **Initial State:** We can start from any state as the initial state.
- **Actions:** Here, actions of the blank space is defined, i.e., either **left, right, up or down**
- **Transition Model:** It returns the resulting state as per the given state and actions.
- **Goal test:** It identifies whether we have reached the correct goal-state.
- **Path cost:** The path cost is the number of steps in the path where the cost of each step is 1.

  Note: The 8-puzzle problem is a type of **sliding-block problem** which is used for testing new search algorithms in artificial intelligence.
- **8-queens problem:** The aim of this problem is to place eight queens on a chessboard in an order where no queen may attack another. A queen can attack other queens either **diagonally or in same row and column.**

  From the following figure, we can understand the problem as well as its correct solution.

It is noticed from the above figure that each queen is set into the chessboard in a position where no other queen is placed diagonally, in same row or column. Therefore, it is one right approach to the 8-queens problem.

For this problem, there are two main kinds of formulation:

- **Incremental formulation:** It starts from an empty state where the operator augments a queen at each step.

Following steps are involved in this formulation:

- **States:** Arrangement of any 0 to 8 queens on the chessboard.
- **Initial State:** An empty chessboard
- **Actions:** Add a queen to any empty box.
- **Transition model:** Returns the chessboard with the queen added in a box.
- **Goal test:** Checks whether 8-queens are placed on the chessboard without any attack.
- **Path cost:** There is no need for path cost because only final states are counted.

In this formulation, there is approximately **1.8×10^{14}** possible sequence to investigate.

- **Complete-state formulation:** It starts with all the 8-queens on the chessboard and moves them around, saving from the attacks.

Following steps are involved in this formulation

- **States:** Arrangement of all the 8 queens one per column with no queen attacking the other queen.
- **Actions:** Move the queen at the location where it is safe from the attacks.

This formulation is better than the incremental formulation as it reduces the state space from **1.8×10^{14}** to **2057**, and it is easy to find the solutions.

Some Real-world problems

- **Traveling salesperson problem(TSP):** It is a **touring problem** where the salesman can visit each city only once. The objective is to find the shortest tour and sell-out the stuff in each city.
- **VLSI Layout problem:** In this problem, millions of components and connections are positioned on a chip in order to minimize the area, circuit-delays, stray-capacitances, and maximizing the manufacturing yield.

The layout problem is split into two parts:

- **Cell layout:** Here, the primitive components of the circuit are grouped into cells, each performing its specific function. Each cell has a fixed shape and size. The task is to place the cells on the chip without overlapping each other.
- **Channel routing:** It finds a specific route for each wire through the gaps between the cells.
- **Protein Design:** The objective is to find a sequence of amino acids which will fold into 3D protein having a property to cure some disease.

Searching for solutions

We have seen many problems. Now, there is a need to search for solutions to solve them.

In this section, we will understand how searching can be used by the agent to solve a problem.

For solving different kinds of problem, an agent makes use of different strategies to reach the goal by searching the best possible algorithms. This process of searching is known as **search strategy.**

Measuring problem-solving performance

Before discussing different search strategies, the **performance measure** of an algorithm should be measured. Consequently, There are four ways to measure the performance of an algorithm:

Completeness: It measures if the algorithm guarantees to find a solution (if any solution exist).

Optimality: It measures if the strategy searches for an optimal solution.

Time Complexity: The time taken by the algorithm to find a solution.

Space Complexity: Amount of memory required to perform a search.

The complexity of an algorithm depends on **branching factor** or **maximum number of successors**, **depth of the shallowest goal node** (i.e., number of steps from root to the path) and **the maximum length of any path in a state space.**

Search Strategies

There are two types of strategies that describe a solution for a given problem:

Uninformed Search (Blind Search)

This type of search strategy does not have any additional information about the states except the information provided in the problem definition. They can only generate the successors and distinguish a goal state from a non-goal state. These type of search does not maintain any internal state, that's why it is also known as **Blind search.**

There are following types of uninformed searches:

- Breadth-first search
- Uniform cost search
- Depth-first search
- Depth-limited search
- Iterative deepening search
- Bidirectional search

Informed Search (Heuristic Search)

This type of search strategy contains some additional information about the states beyond the problem definition. This search uses problem-specific knowledge to

find more efficient solutions. This search maintains some sort of internal states via heuristic functions (which provides hints), so it is also called **heuristic search.**

There are following types of informed searches:

- Best first search (Greedy search)
- A* search

TOPIC:General Problem Solving:

It was the first useful computer program that came into existence in the AI world. The goal was to make it work as a universal problem-solving machine.GPS was the first program that was intended to solve any general problem

To program the GPS, the authors created a new language called **Information Processing Language** (**IPL**). The basic premise is to express any problem with a set of well-formed formulas. In a graph, the source refers to the starting node and the sink refers to the ending node.

Even though GPS was intended to be a general purpose, it could only solve well-defined problems, such as proving mathematical theorems in geometry and logic. It could also solve word puzzles and play chess.

Solving a problem with GPS:

Let's see how to structure a given problem to solve it using GPS:

1. The first step is to define the goals. Let's say our goal is to get some milk from the grocery store.

2. The next step is to define the preconditions. These preconditions are in reference to the goals. To get milk from the grocery store, we need to have a mode of transportation and the grocery store should have milk available.
3. After this, we need to define the operators. If my mode of transportation is a car and if the car is low on fuel, then we need to ensure that we can pay the fueling station. We need to ensure that you can pay for the milk at the store.

An operator takes care of the conditions and everything that affects them. It consists of actions, preconditions, and the changes resulting from taking actions. In this case, the action is giving money to the grocery store. Of course, this is contingent upon you having the money in the first place, which is the precondition. By giving them the money, you are changing your money condition, which will result in you getting the milk.

There are many applications of machine learning that exist today. It is used in image recognition, robotics, speech recognition, predicting stock market behavior, and so on.

Topic:Characterstic of problems:

In order to choose the most appropriate problem solving method, it is necessary to analyze the problem along various key dimensions.

- **Is the problem decomposable into a set of independent smaller or easier sub-problems?**

A very large and composite problem can be easily solved if it can be broken into smaller problems and recursion could be used.

For example, we want to solve :- $\int x2 + 3x + sin2x\ cos2x\ dx$

This can be done by breaking it into three smaller problems and solving each by applying specific rules. Adding the results we can find the complete solution.But there are certain problems which cannot be decomposed into sub-problems.

For example Blocks world problem in which, start and goal state are given as,

Here, solution can be achieved by moving blocks in a sequence such that goal state can be derived.

Can solution steps be ignored or at least undone if they prove unwise?

Problem fall under three classes, (i) ignorable, (ii) recoverable and (iii) irrecoverable.

This classification is with reference to the steps of the solution to a problem.Consider theorem proving. We may later find that it is of no use. We can still proceed further, since nothing is lost by this redundant step. This is an example of ignorable solutions steps.

Now consider the 8 puzzle problem tray and arranged in specific order.

While moving from the start state towards goal state, we may make some stupid move but we can backtrack and undo the unwanted move. This only involves additional steps and the solution steps are recoverable.

Lastly consider the game of chess. If a wrong move is made, it can neither be ignored nor be recovered. The thing to do is to make the best use of current situation and proceed. This is an example of an irrecoverable solution steps.

❖ Is the problem's universe predictable?

Problems can be classified into those with certain outcome (eight puzzle) and those with uncertain outcome (playing cards).

In certain — outcome problems, planning can be done to generate a sequence of operators that guarantees to lead to solution.

Planning helps to avoid unwanted solution steps.

For uncertain outcome problems, planning can at best generate a sequence of operators that has a good probability of leading to a solution.

❖ What is the role of knowledge

Though one could have unlimited computing power, the size of the knowledge base available for solving the problem does matter in arriving at a good solution.

Take for example the game of playing chess, just the rules for determining legal moves and some simple control mechanism is sufficient to arrive at a solution.

But additional knowledge about good strategy and tactics could help to constrain the search and speed up the execution of the program. The solution would then be realistic.

Exhaustive Searches:

Many important problems require finding an element with a special property in a domain that grows exponentially (or faster) with an instance size. Typically, such problems arise in situations that involve—explicitly or implicitly—combinatorial objects such as permutations, combinations, and subsets of a given set. Many such problems are optimization problems: they ask to find an element that maximizes or minimizes some desired characteristic such as a path length or an assignment cost.

We illustrate exhaustive search by applying it to two important problems: the traveling salesman problem, and the knapsack problem.

1. Traveling Salesman Problem:

The ***traveling salesman problem (TSP)*** has been intriguing researchers for the last 150 years by its seemingly simple formulation, important applications, and interesting connections to other combinatorial problems. In layman's terms, the problem asks to find the shortest tour through a given set of ***n*** cities that visits each city exactly once before returning to the city where it started. The problem can be conveniently modeled by a weighted graph, with the graph's vertices representing the cities and the edge weights specifying the distances. Then the problem can be stated as the problem of finding the shortest ***Hamiltonian circuit*** of the graph. (A

Hamiltonian circuit is defined as a cycle that passes through all the vertices of the graph exactly once. It is named after the Irish mathematician Sir William Rowan Hamilton (1805–1865), who became interested in such cycles as an application of his algebraic discoveries.)

It is easy to see that a Hamiltonian circuit can also be defined as a sequence of $n + 1$ adjacent vertices $v_{i0}, v_{i1}, \ldots, v_{in-1}, v_{i0}$, where the first vertex of the sequence is the same as the last one and all the other $n - 1$ vertices are distinct. Further, we can assume, with no loss of generality, that all circuits start and end at one particular vertex (they are cycles after all, are they not?). Thus, we can get all the tours by generating all the permutations of $n - 1$ intermediate cities, compute the tour lengths, and find the shortest among them.

An inspection of Figure 3.7 reveals three pairs of tours that differ only by their direction. Hence, we could cut the number of vertex permutations by half. We could, for example, choose any two intermediate vertices, say, ***b*** and ***c***, and then consider only permutations in which ***b*** precedes ***c***. (This trick implicitly defines a tour's direction.)

2.Knapsack Problem:

Here is another well-known problem in algorithmics. Given n items of known weights $w_1, w_2, \ldots, w_n$ and values $v_1, v_2, \ldots, v_n$ and a knapsack of capacity W, find the most valuable subset of the items that fit into the knapsack. If you do not like the idea of putting yourself in the shoes of a thief who wants to steal the most.

Heuristic Search:

A Heuristic is a technique to solve a problem faster than classic methods, or to find an approximate solution when classic methods cannot. This is a kind of a shortcut as we often trade one of optimality, completeness, accuracy, or precision for speed. A Heuristic (or a heuristic function) takes a look at search algorithms. At each branching step, it evaluates the available information and makes a decision on which branch to follow.

It does so by ranking alternatives. The Heuristic is any device that is often effective but will not guarantee work in every case.

So *why do we need heuristics*? One reason is to produce, in a reasonable amount of time, a solution that is good enough for the problem in question. It doesn't have to be the best- an approximate solution will do since this is fast enough.

Most problems are exponential. Heuristic Search let us reduce this to a rather polynomial number. We use this in AI because we can put it to use in situations where we can't find known algorithm.