21CSC206T-
ARTIFICIAL INTELLIGENCE

Unit I

OVERVIEW

Introduction to AI- AI techniques, Problem solving with AI, AI Models, Data acquisition and learning aspects in AI, Problem solving- Problem solving process, formulating problems, Problem types and characteristics, Problem space and search, Toy Problems – Tic-tac-toe problems, Missionaries and Cannibals Problem, Real World Problem – Travelling Salesman Problem

WHAT IS ARTIFICIAL INTELLIGENCE?

According to Rich and Knight

"AI is the study of how to make computers do things which at the moment, people do better"

It is a branch of science which makes machine intelligent enough in comparable to people.

Involves the study of Psychology (human), giving human reactions to machine and also mathematical modelling to optimize.

Process of AI includes:

Knowledge Transmission

Knowledge Representation- Facts, Object, Events etc.

Automated Reasoning

AI- HISTORY AND FOUNDATIONS

- AI entered the mainstream before 60 years. In 1940 Konrad Zuse developed artificial chess playing using high level language called Plankalkul.
- Alan Turing, British mathematician is the one of the first people to come up with the idea of machines that think in 9150.
- He created the Turing test, which is still used today as a bench mark to determine a machine's ability to think like a human.
- A computer program called Eugene Goostman, which simulates a 13-year-old Ukrainian boy, is said to have passed the Turing test at an event organised by the University of Reading.
- Isaac Asimov, was an American writer and professor of biochemistry at Boston University. He proposed three laws of robotics.
  - First Law: A robot may not injure a human being or through in action allow a human being to come to harm.
  - Second Law: A robot must obey the orders given it by human beings except where such orders would conflict with the first law.
  - Third Law: A robot must protect its own existence as long as such protection does not conflict with the first or second law.

AI- HISTORY AND FOUNDATIONS

- 1951 – first AI based program was written [a checkers playing program written by Christopher Strachey and a chess playing program written by Dietrich Prinz]
- 1955- first self learning game playing [competing against human players in the game of checkers]
- 1959- MIT –AI based lab setup
- 1961- frist robot is introduced in general motors
- 1964 – first demo of AI program which understand natural language
- 1965- first chat bot Eliza was invented
- 1974- first autonomous vehicle
- 1989- Carnegie Mellon created the first autonomous vehicle using neural network called ALVINN

AI- HISTORY AND FOUNDATIONS

- 1996- IBM's deep blue- chess playing game
  - Deep Blue won its first game against world champion Garry Kasparov in game on 10 Feb 1988.
- 1999- Sony introduces AIBO- self learning entertaining robot
- 2004 – DARPA (Defense Advanced Research Project Agency) introduce vehicle challenge
- 2009- Google- started to build a self driving car
- 2010- narrative science AI demonstrate ability to write reports
- 2011- IBM Watson beats jeopardy champions [Brad Rutter and Ken Jennings]- quiz game
- 2011- Google now and Cortana becomes the mainstream
- 2016- Stanford issues the AI 100 reports
- 2016- University of California, Berkley launches the center human compatible AI

APPLICATIONS OF AI

E-Commerce

Personalization: Using this feature, customers would be able to see those products based on their interest pattern and that eventually will drive more conversions.

Enhanced Support: It's very important to attend to every customer's query to reduce the churn ratio and to empower that AI-powered chatbots are well capable of handling most of the queries that too 24×7.

Fake Review Detection: A report suggested that 9 out of 10 people tend to go through customer reviews first before they actually place any order.

Voice Search: With the introduction of this feature, many applications and websites are using voice-over searches in their system. Today, 6 out of 10 prefer to use this feature for online shopping.

Robotics

NLP: Natural Language Processing plays a vital role in robotics to interpret the command as a human being instructs.

Object Recognition & Manipulation: This functionality enables robots to detect objects within the perimeter and this technique also helps robots to understand the size and shape of the object.

HRI: With the help of AI algorithms, HRI or Human-Robotics Interaction is being developed that helps in understanding human patterns such as gestures, expressions etc.

APPLICATIONS OF AI

GPS and Navigations

Voice Assistance: This feature allows users to interact with the AI using a hands-free feature & which allows them to drive seamlessly while communicating through the navigation system.

Personalization (Intelligent Routing): The personalized system gets active based on the user's pattern & behavior of preferred routes. Irrespective of the time & duration, the GPS will always provide suggestions based on multiple patterns & analyses.

Traffic Prediction: AI uses a Linear Regression algorithm that helps in preparing and analyzing the traffic data. This clearly helps an individual in saving time and alternate routes are provided based on congestion ahead of the user.

Healthcare

Insights & Analysis: With the help of AI, a collection of large datasets, that includes clinical data, research studies, and public health data, to identify trends and patterns.

Telehealth: This feature enables doctors and healthcare experts to take close monitoring while analyzing data to prevent any uncertain health issues.

Agriculture

Crop Monitoring: To have rigorous monitoring, and ensure that crops that not being affected by any disease.

Forecasting: With the help of AI, analyzing the weather forecast and crop growth has become more convenient in the field of agriculture and the algorithms help farmers to grow crops with effective business decisions.

APPLICATIONS OF AI

Lifestyle

Personalized Recommendation: AI algorithms analyze user purchasing patterns & based on which offer personalized recommendations for different categories which includes books, clothing, movies etc.

Virtual Assistance: There are certain apps now that have started offering enriched customer experience by adding virtual assistance to their ecosystem. AI-powered virtual assistants like Siri, Google Assistant, Alexa, and Cortana play a crucial part in this.

Social media

Fraud Detection: AI uses algorithms to spot and remove any fake accounts that are associated with any social media platform. Fraudsters generally use those accounts to perform unethical activities.

Sentiment Analysis: People are more connected and likely to spend more time on social media platforms. It definitely adds value to an individual's life and is connected with their emotions. AI uses its algorithm to determine the pattern to provide a better experience while maintaining awareness.

Chatbots

NLP: Natural Language Processing empowers chatbots to interact with humans over chat in a more interactive way by offering quick resolution to their queries in no time. It also allows chatbots to process text or speech inputs, and extract meaning to generate the desired response.

Multi-Language: AI-powered chatbots are capable of handling multiple languages to provide support to users worldwide. NLP algorithms enable chatbots to understand and generate responses in different languages to cater to a vast community for extensive support.

APPLICATIONS OF AI

Surveillance

Object Detection: With the help of CN, AI algorithms help in tracking objects of interest in real time. This feature allows the system to detect any object's movement as & when required for further analysis.

Behavior Analysis: Body gesture says it all & that's why AI in surveillance can analyze human behavior patterns, such as gesture recognition or body language analysis, to assess potential threats or suspicious activities.

Finance

Risk Assessment: AI algorithms help in enabling safeguard risk assessment models by analyzing large datasets and identifying potential risks in real-time.

Forecasting: AI-powered tools can assist in financial planning and forecasting that can create easy opportunities for businesses to make effective business decisions. This can be achieved by analyzing historical data, market trends, and economic indicators.

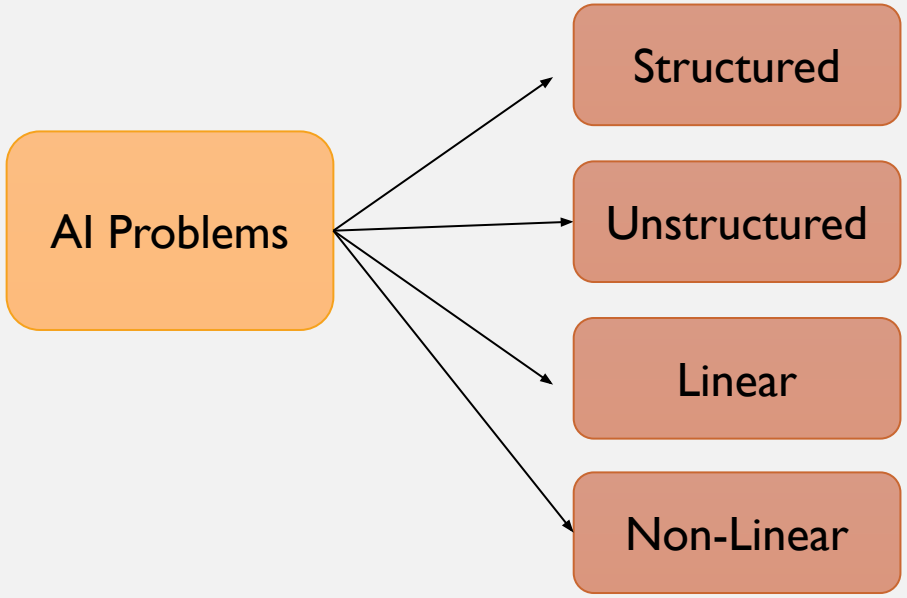
AI TECHNIQUES

- AI deals with large spectrum of problems. The spectrum of AI applications is spread across the domains and even across the complexities of problems.
- Such as day- to- day practical problems, classification problems resulting in decision making and cross-domain problems.
- The generalization may become very difficult in case of these problems, because the problems are complex and hard to resolve.
- The main reason of the complexity is the dynamic nature of these problems unlike some routine mathematical problem.
- Hence AI techniques need to look at these problems from analysis perspective and try to resolve them.

NEED FOR AI TECHNIQUES

- Analysis of voluminous and large amount of data.
- Analysis should be followed by the characterization of miscellaneous data, then mapping of this data with reference to built-in knowledge, then building the knowledge further in this process.
- Dealing with the constantly changing scenarios and situations and the dynamic nature of the data, the system and the technique should react to the new scenario and situation.
- The way in which data appears, the way it is used and the way it is organized are different. Blindly using the data as it comes may result in wrong decision.
- In some cases, the huge data is available, but the relevant data is limited. Identification of relevant data, irrelevant data and outliers are the challenges in front of AI techniques.

CATEGORIES OF PROBLEM IN AI

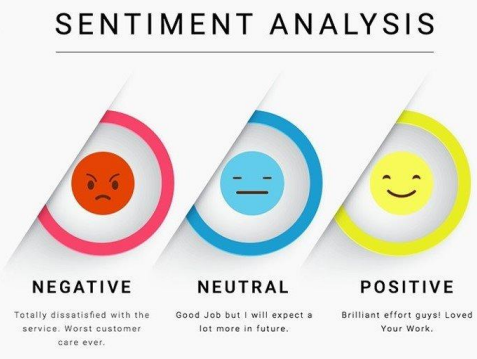


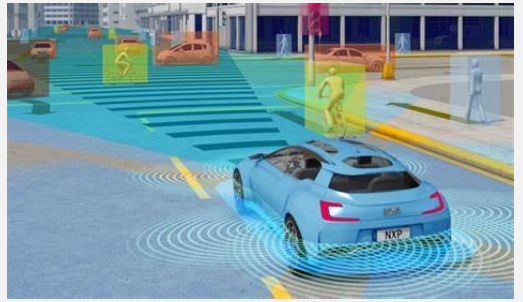
STRUCTURED PROBLEM

- A structured problem refers to a problem with a well-defined and clearly understood set of rules, constraints, and solution methods. These problems are typically characterized by having a known input, a clear set of operations or steps to follow, and a definite output.
- Examples: solving a quadratic equation to find out the value of X, sorting algorithms, chess game etc.

UNSTRUCTURED PROBLEM

- A problem that lacks clear, well-defined rules, constraints, or a predetermined solution path. These problems often involve complex and ambiguous situations where the desired outcome is not precisely known, and there may be multiple valid solutions.
- Examples: autonomous driving, medical diagnosis, sentiment analysis, predicting how to dispose wet waste safely etc.



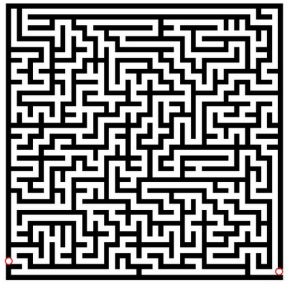


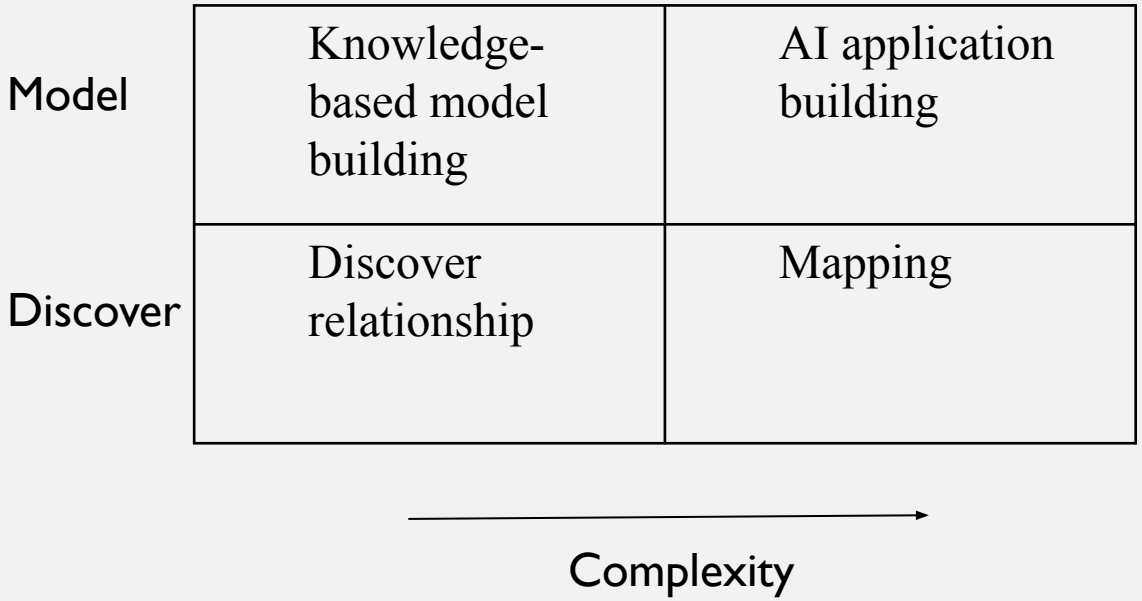
LINEAR AND NON LINEAR PROBLEMS

- Linear Problems – are one with definitely have a solution or there will not be any solution. These problems falls under the classification category.
- Non-Linear Problems -involve relationships or behaviors that cannot be accurately modeled using linear equations. In contrast to linear problems, these issues exhibit nonlinear patterns, dependencies, or interactions between variables.

AI MODELS

- One important aspect of building AI solutions is modelling the problem. Modelling the problem means representation of a situation that allows analysis, understanding and potentially solving the problem.
- The term ‘maze hypothesis’ in AI refers- 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 point of time analyze maze, for choices, could find those which can lead to goal.





Complexity of model building with reference to data and knowledge mapping

- Semiotic models: Semiotic models involve the study and application of semiotics, which is the field of study that examines signs, symbols, and meaning.
- Examples: Natural Language Processing, Image and Video Analysis, Sentiment Analysis etc.
- Statistical Models: a statistical model is a mathematical representation or framework that leverages statistical techniques to analyze and make predictions based on data. These models use statistical methods to learn patterns, relationships, and distributions within the data, allowing them to make informed decisions or predictions when faced with new, unseen data.
- Examples: Disease prediction, Spam filtering etc.

DATA ACQUISITION AND LEARNING ASPECTS IN AI

Knowledge discovery- Data mining and machine learning: information can be referred to as pattern underlying the data, whereas the data refers to recorded facts. The term data mining or knowledge discovery is the extraction of meaningful information that is previously unknown and can be useful potentially ahead.

Machine learning 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.

Computational Learning Theory (COLT): computational learning theory (COLT) plays a significant role in understanding the principles, limitations, and efficiency of learning algorithms.

Neural and evolutionary computation: it is a new technique to speed up the mining of data. Neural computation is inspired by the structure and functioning of the human brain. Evolutionary computation is inspired by the process of natural selection and evolution.

Intelligent and multi- agent systems: an agent in simple terms, is a software program that assists user.

An intelligent agent is an entity, typically a software program or system, that perceives its environment, processes information, and takes actions to achieve specific goals.

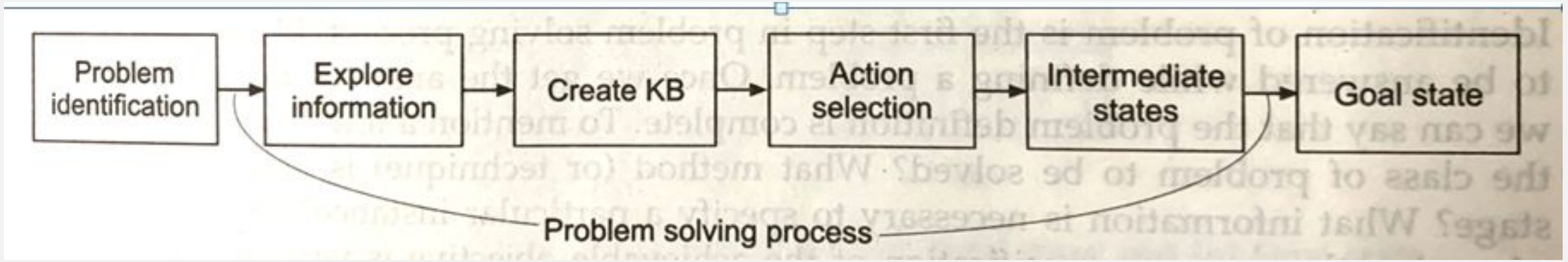
A multiple-agent system involves a group of intelligent agents that interact with each other and their environment. These agents can be independent entities pursuing individual goals or can collaborate to achieve shared objectives.

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.

PROBLEM SOLVING

- Problem solving is an area to deal with finding answer for some unknown situations.
- It involves understanding, representation, formulation and solving. It encapsulates two types of problems- simple and complex.
- The methods of problem solving can be classified as:
  - General purpose- applied to a wide range of problems
  - Special purpose- the application is narrowed down to a specific purpose

PROBLEM SOLVING PROCESS



The term problem can be defined with following conditions:

1. Every problem is defined in a context. In this context, it has certain assumptions under initial conditions.
2. Every problem has a well defined objective
3. Solution to every problem consist of set of activities. Each activity changes the state of problem (from present state to new state). This new state is closer to the solution state.
4. Previous knowledge and domain knowledge both are used as resources during different states in the solution process.

PROBLEM TYPES AND CHARACTERISTICS

Deterministic or observable: this type of problem are also known as single-state problem.

Each state is fully observable and it goes to one definite state after any action.

Here the goal state is reachable on one single action or sequence of action.

Example: Vacuum cleaner with sensor.

Non-Observable: this type of problem are also called as multiple- state problems. The problem solving agent does not have any information about the state. Application of operator can lead to multiple states. Here the solution may or may not be reached.

Example: Vacuum cleaner without sensor.

Non-deterministic or partially observable: in this type of problem, the effect of action is not clear. In every new state, some new information is added and then operator acts on the state.

Solution space is a tree structure of states. Solution is based on searching the tree and finding out the path for solution.

Example: Vacuum cleaner with sensor.

Unknown state space: this type of problems are typically exploration problem. States and impact of action are unknown.

Example: Online search.

PROBLEM ANALYSIS AND REPRESENTATION

- A problem representation is a complete view of the problem and the approach to solve it.
- The performance of any intelligent system depends on the problem representation formulation.
- The problem representation is a important step to understand before we start solving the problem.
- The quality and the appropriateness of solution depends on the completeness of the problem definition.

PROBLEM DEFINITION

The problem definition should satisfy the following criteria:

1. Compactness: must be able to restrict and define boundaries clearly
2. Utility: must compatible with solution algorithms
3. Soundness: should not report false positive or false negative
4. Completeness: should not loose any information
5. Generality: should be able to capture all possible instance of the problem
6. Transparency: reasoning with the representation efficiently

Example: Smart Home

WATER JUG PROBLEM

- The problem is defined as follows:
  - There are two jugs without scale measurement. One of the two jugs has 5 gal capacity and the other is smaller has 2 gal capacity.

Problem: to find out a way to empty 2 gal jug and fill 5 gal jug with 1 gal water.

States: amount of water in the jugs

Actions: Empty the big jug

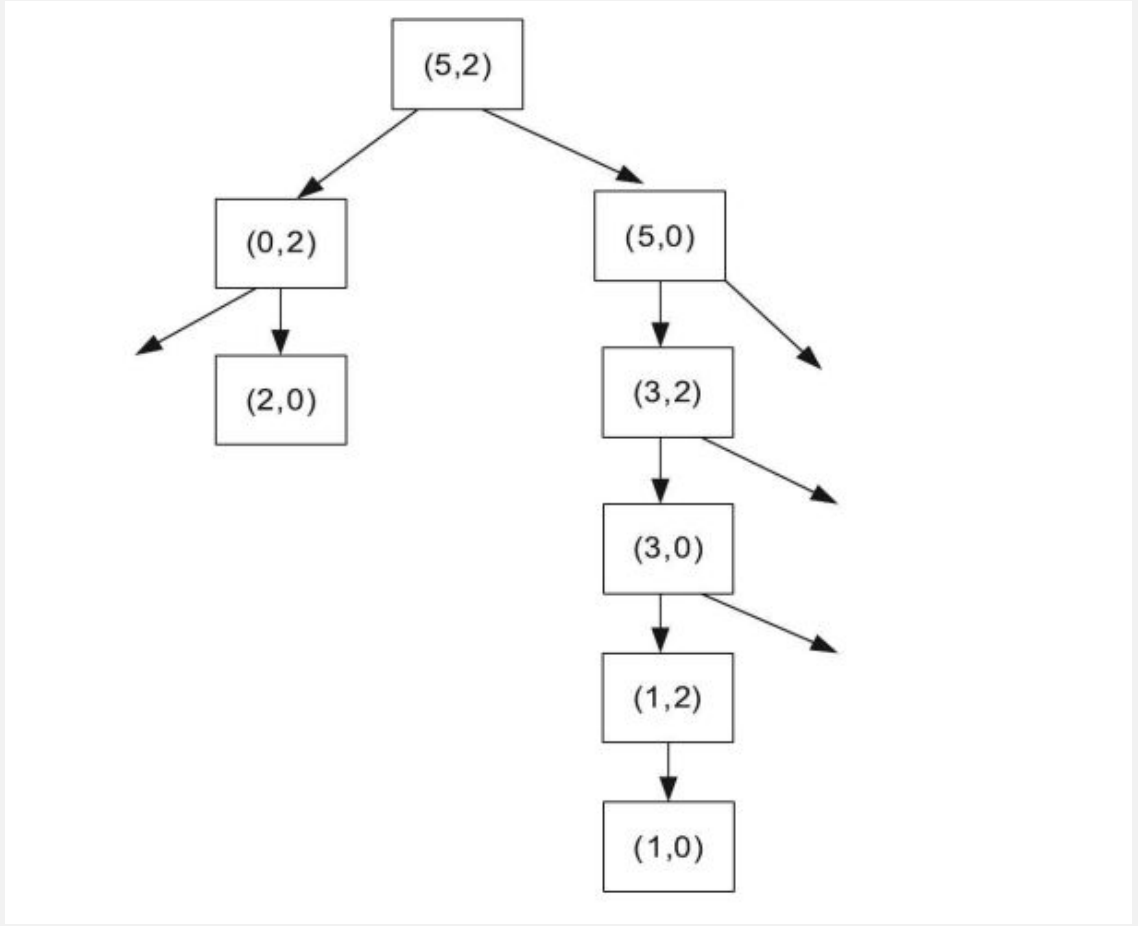
Empty the small jug

Pour water from small jug to big jug

Pour water from big jug to small jug

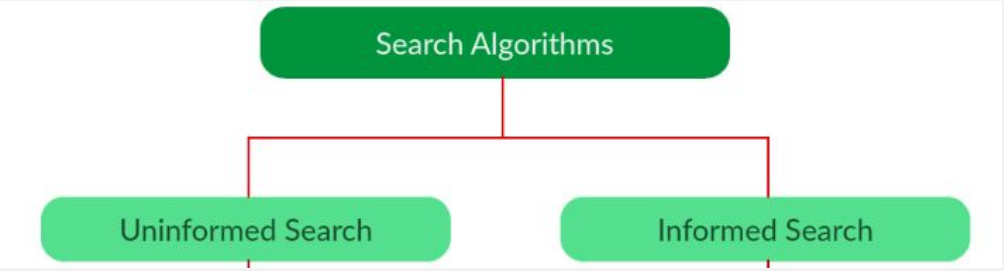
Goal: to get the specified amount of water (1 gal) and to empty the smaller jug

Path cost: number of action applied


(5,2)
(0,2)
(5,0)
(2,0)
(3,2)
(3,0)
(1,2)
(1,0)

PROBLEM SPACE AND SEARCH

- Search is a general algorithm that helps in finding the path in the state space. Every problem can be solved with the help of search. It consist of one or more path.
- The path may lead to the solution or might be dead end. Incase of dead end backtrack should occur. The search algorithm make use of backward and forward search.
- The search algorithm identify and adopt a strategy to explore the states. The two types of strategies are: uninformed and informed search.



- **Informed search:** The informed search algorithm is more useful for large search space. Informed search algorithm uses the idea of heuristic, so it is also called Heuristic search.
- Heuristic is a function which is used in Informed Search, and it finds the most promising path. It takes the current state of the agent as its input and produces the estimation of how close agent is from the goal.
- The heuristic method, however, might not always give the best solution, but it guaranteed to find a good solution in reasonable time.
- **Uninformed search:** Uninformed search algorithms operate without any knowledge about the problem domain or the goal location.
- These algorithms explore the search space systematically without considering any information about the states or the potential solutions.

WATER JUG PROBLEM

Representation of water jug problem

- State : (x,y)
- where x represents the 5 liter jug and y represents the 2 liter jug.
- Start State: (5,2)
- Goal State: (1,0)
- Action: empty the big jug, empty the small jug, pour water from big jug to small
- Here we need to start from the start state and end up in a goal state.

PRODUCTION RULE FOR WATER JUG PROBLEM

S.No	Rule	Description
1	(x,y), if x>0,(0,y)	Empty the 5 liter jug
2	(x,y), if y>0, (x,0)	Empty the 2 liter jug
3	(x,y), if x>0, (x-d,y+d)	Pour some water from 5 liter jug to 2 liter jug
4	(x,y), if y>0,(x+d,y-d)	Pour some water from 2 liter jug to 5 liter

SOLUTION

S.No	Rule	Description
1	(x,y) if y>0, (x,0)	Empty the 2 liter jug
2	(x,y) if x>0, (x-d, y+d)	Pour some water from 5 liter jug to 2 liter jug
3	(x,y) if y>0, (x,0)	Empty the 2 liter jug
4	(x,y) if x>0, (x-d, y+d)	Pour some water from 5 liter jug to 2 liter jug
5	(x,y), if y>0, (x,0)	Empty the 2 liter jug

MISSIONARIES AND CANNIBALS PROBLEM

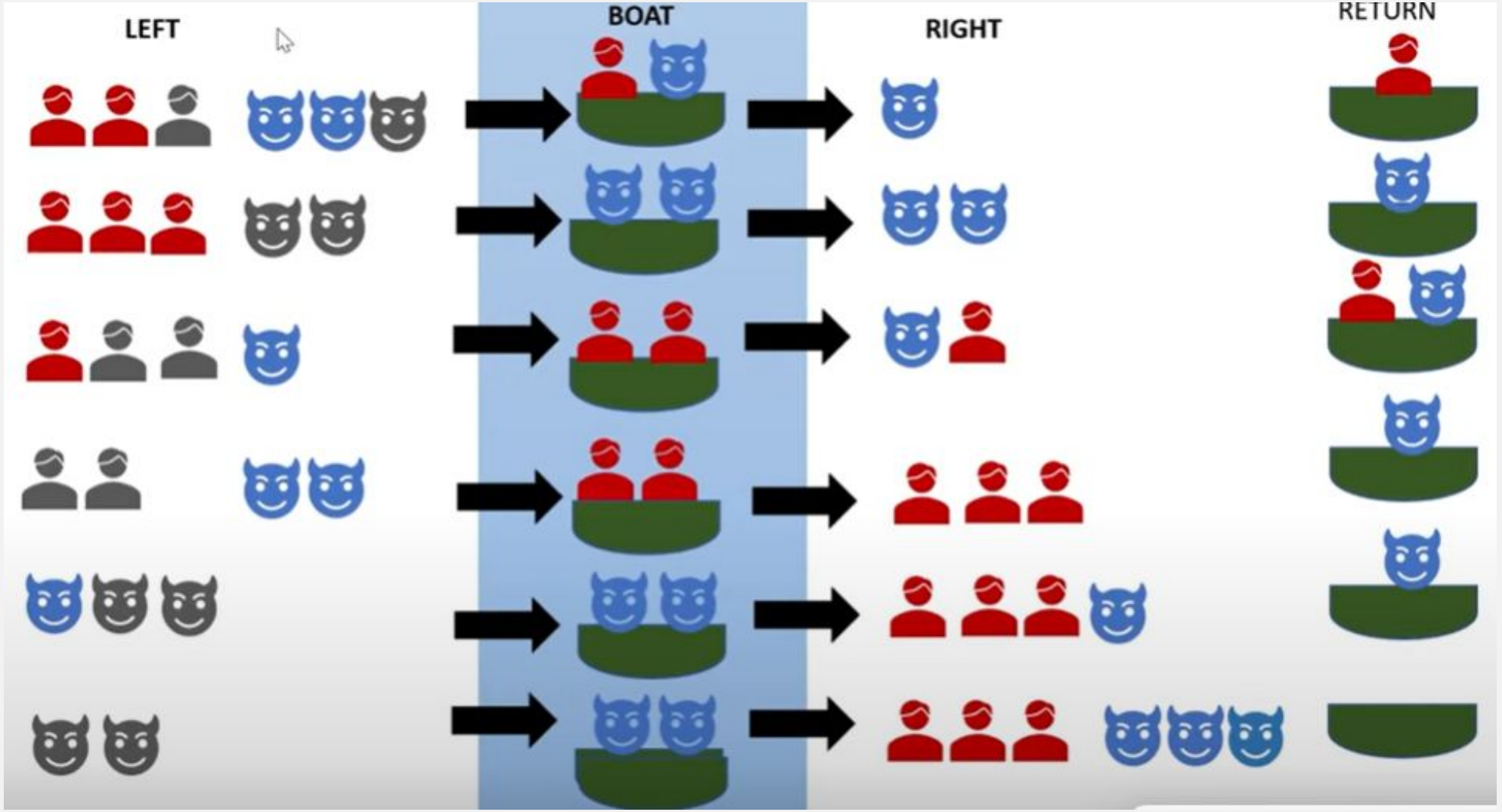
Representation of the problem:

- Initial State: 3 missionaries, 3 cannibals and the boat on the left side of the river.
- Goal State: 3 missionaries, 3 cannibals and the boat on the right side of the river.
- Constraints: missionaries can never be outnumbered by the cannibals on either side of the river. Boat cannot go to and fro as empty.
- Actions: Move the boat from left to right

  Move the boat from right to left

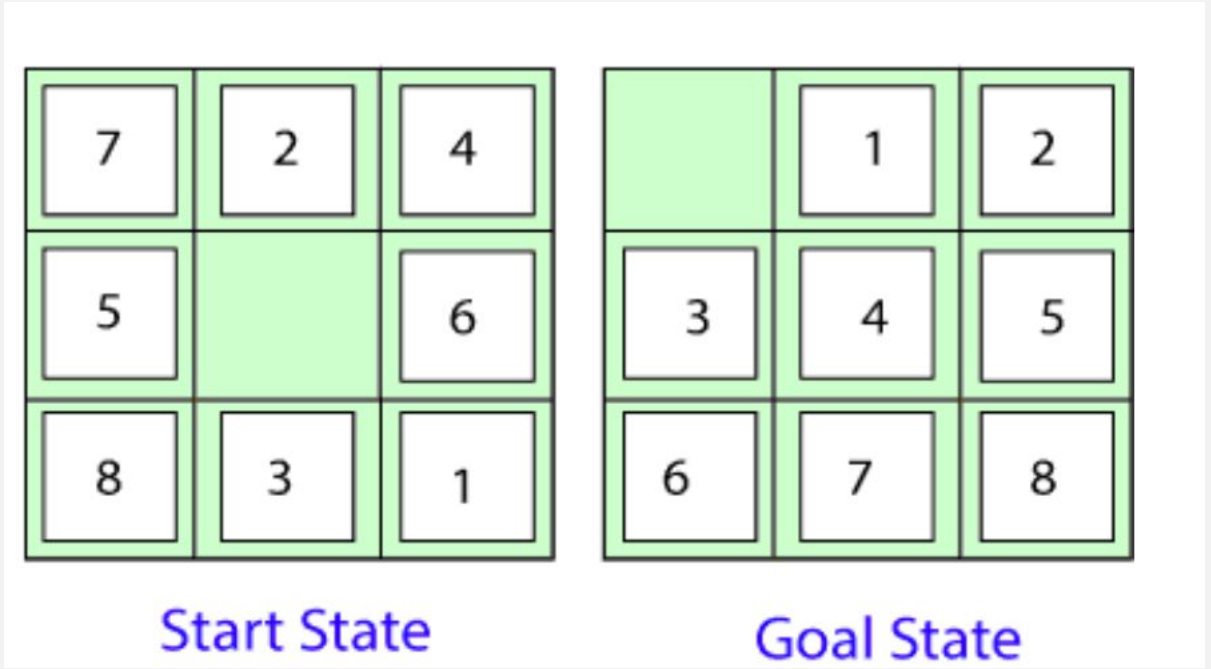
PRODUCTION RULE

S.No	Rule	Description
1	(0,M)	One missionary from left to right
2	(M,0)	One missionary from right to left
3	(M,M)	Two missionaries from left to right or from right to left
4	(C,C)	Two cannibals from left to right or from right to left
5	(0,C)	One cannibal from left to right
6	(C,0)	One cannibal from right to left
7	(M,C)	One missionary and one cannibal from left to right or from right to left


LEFT
BOAT
RIGHT
RETURN

SOLUTION

Action	Left	Boat	Right
A missionary & Cannibal	MMMCCC	MC	C
Two cannibals	MMMCC	CC	CC
Two missionaries	MMMC	MM	CM
Two missionaries	MMCC	MM	MMM
Two cannibals	CCC	CC	MMMC
Two cannibala	CC	CC	MMMCCC


7 2 4
5 6
8 3 1
Start State
1 2
3 4 5
6 7 8
Goal State