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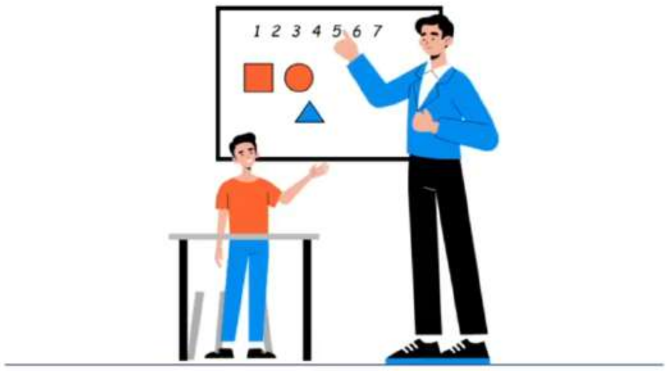
Topics to be covered...

State space approach
Search strategies
Informed vs Uninformed
BFS and DFS
Heuristic Function
Hill climbing algorithm
Water jug problem
Constraint Satisfaction Problems
Backtracking
Game playing good candidate
Min-Max Procedure
Alpha-beta pruning
Happy Ending!



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State space approach

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State space approach

- State space search is a process used in the field of computer science, including artificial intelligence (AI), in which successive configurations or states of an instance are considered, with the intention of finding a goal state with the desired property.
- A State space is the set of all states reachable from the initial state.
- A state space forms a graph in which the nodes are states.
- In the state space, a path is a sequence of states connected by a sequence of actions.

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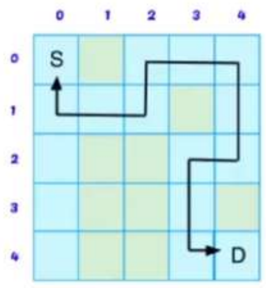
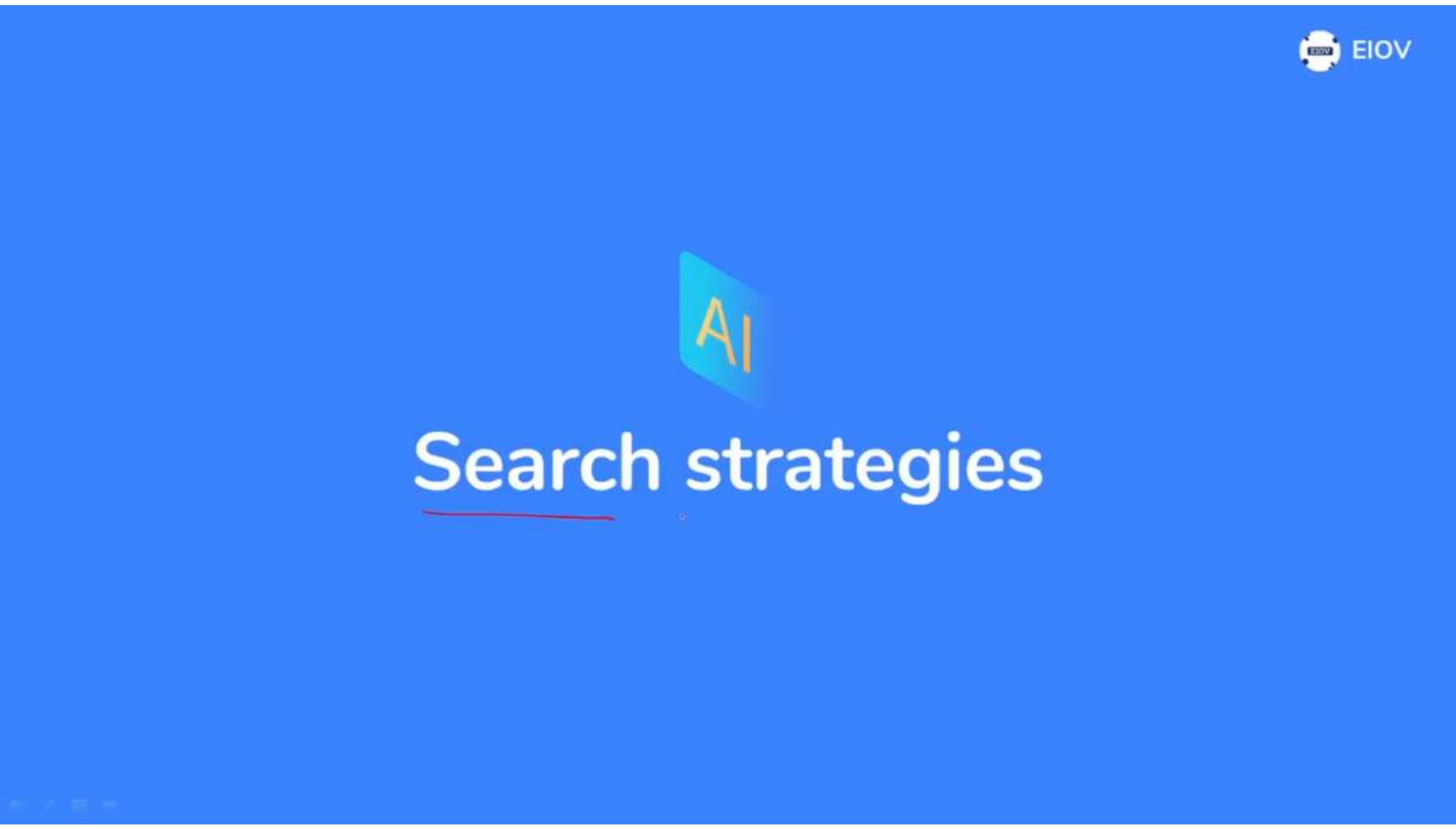
State space approach example

- A maze problem can be represented as a state-space
- Each state represents “where you are” that is the current position in the maze
- The start state or initial state represents your starting position
- The goal state represents the exit from the maze.
- Rules (for a rectangular maze) are: move north, move south, move east, and move west.

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AI

Search strategies

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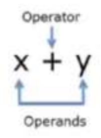
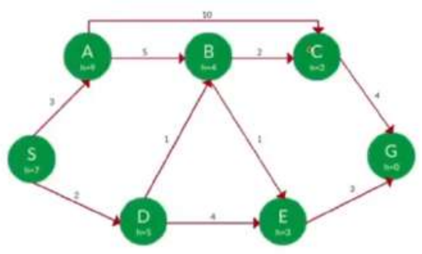
Searching Process

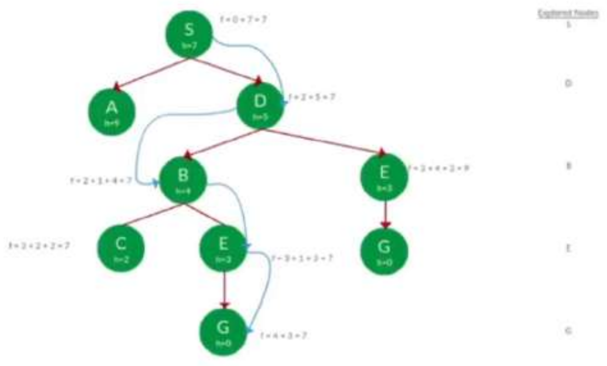
Searching

- Searching is the sequence of steps that transforms the initial state to the goal state.

- The process of search includes:
  - Initial state description of the problem.
  - A set of legal operators that change the state.
  - The finel or goal state.







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Parameters used to evaluate a search technique

1. Completeness

- A search algorithm is said to be complete if it guarantees to return a solution if at least any solution exists for any random input.

2. Optimality

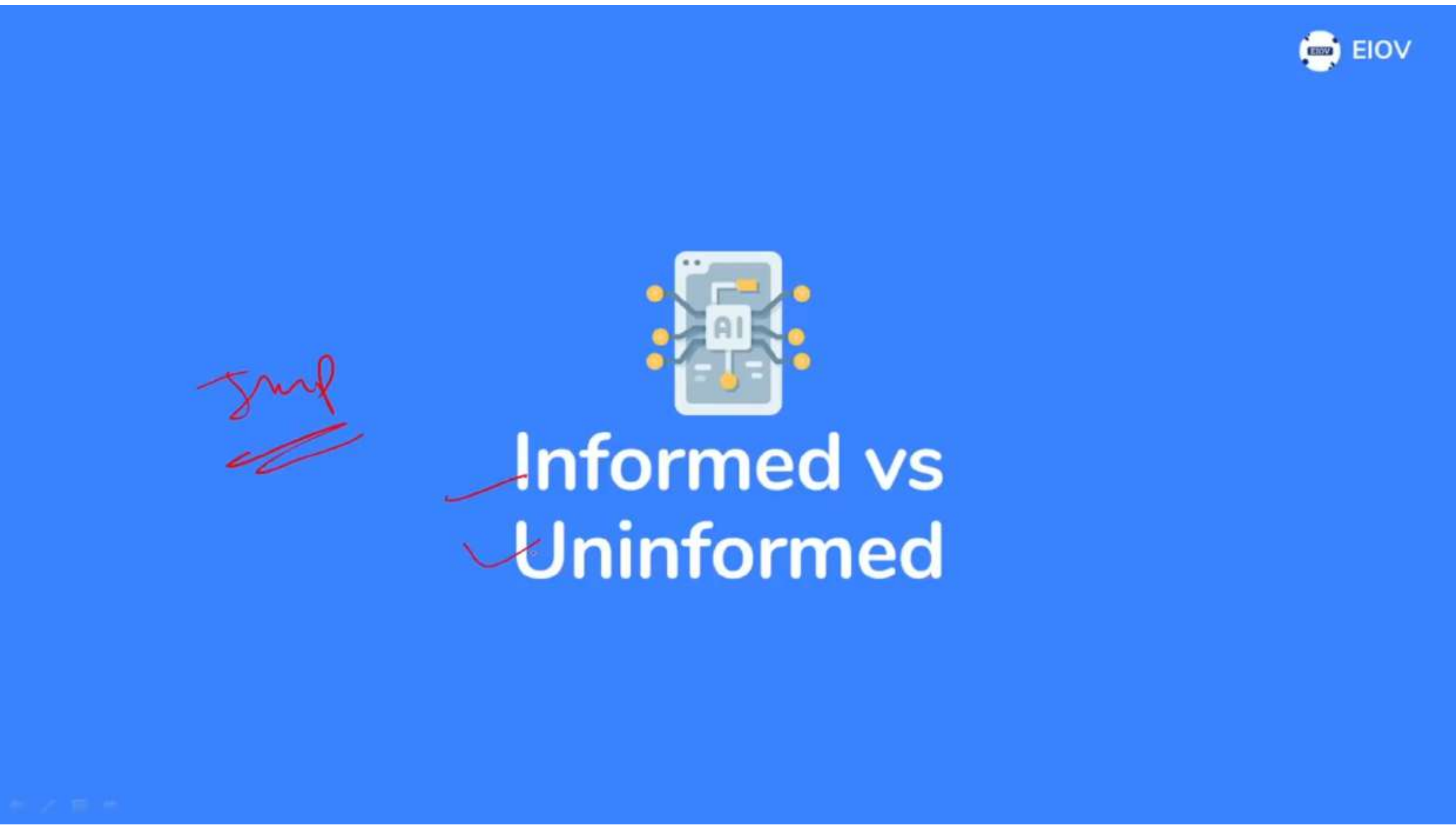
- If a solution found for an algorithm is guaranteed to be the best solution (lowest path cost) among all other solutions.

3. Time Complexity

- Time complexity is a measure of time for an algorithm to complete its task.

4. Space Complexity

- It is the maximum storage space required at any point during the search, as the complexity of the problem.



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Informed vs Uninformed

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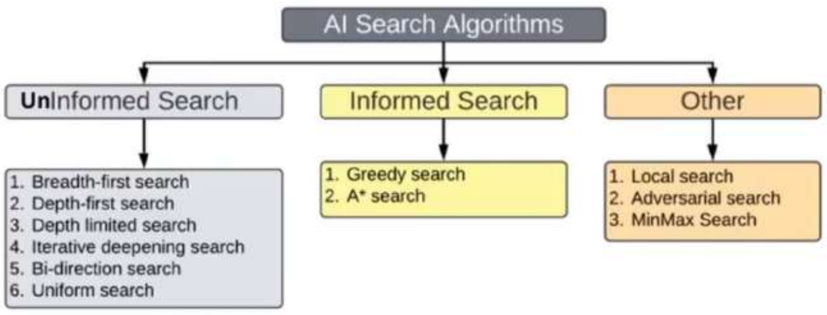
Informed vs Uninformed



Informed vs Uninformed

Uninformed

- The uninformed search does not contain any domain knowledge such as closeness, the location of the goal.
- It operates in a brute-force way.
- Search tree is searched without any information about the search space like initial state operators and test for the goal, so it is also called blind search.

Informed

- Informed search algorithms use domain knowledge.
- A heuristic is a way which might not always be guaranteed for best solutions but guaranteed to find a good solution in reasonable time.

Uninformed (Blind search) search and informed search (Heuristic search) algorithms.

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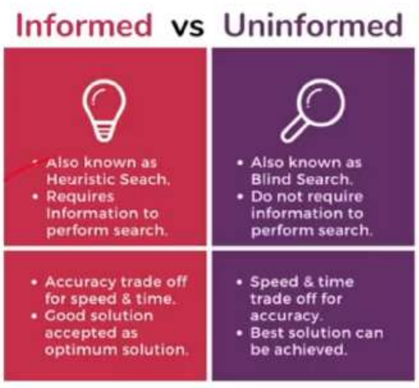
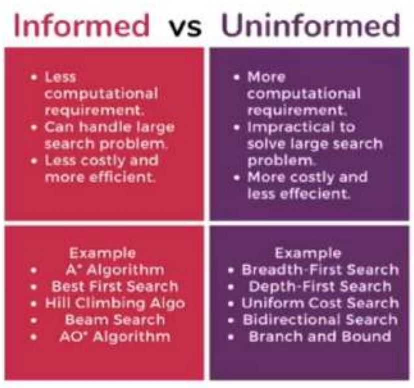
Informed vs Uninformed



Informed	Uninformed
• Also known as Heuristic Seach. • Requires Information to perform search.	• Also known as Blind Search. • Do not require information to perform search.
• Accuracy trade off for speed & time. • Good solution accepted as optimum solution.	• Speed & time trade off for accuracy. • Best solution can be achieved.



Informed	Uninformed
• Less computational requirement. • Can handle large search problem. • Less costly and more efficient.	• More computational requirement. • Impractical to solve large search problem. • More costly and less effecient.
Example • A^* Algorithm • Best First Search • Hill Climbing Algo • Beam Search • AO^* Algorithm	Example • Breadth-First Search • Depth-First Search • Uniform Cost Search • Bidirectional Search • Branch and Bound

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BFS and DFS

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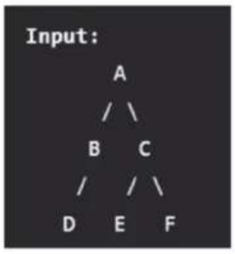
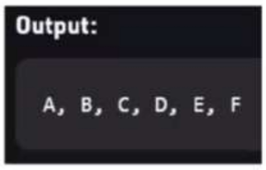
BFS(Breadth First Search)

- BFS stands for Breadth First Search.
- It is also known as level order traversal.
- The Queue data structure is used for the Breadth First Search traversal.
- When we use the BFS algorithm for the traversal in a graph, we can consider any node as a root node.
- It is slower than DFS.



```
Input:
        A
       / \
      B   C
     /   / \
    D   E   F
```



```
Output:
  A, B, C, D, E, F
```

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unit-3

BFS(Breadth First Search)

✓**Advantage**

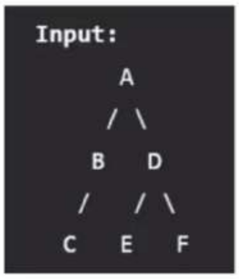
- If there is more than one solution for a given problem, then BFS provides the minimal solution which requires the least number of steps.

Disadvantage

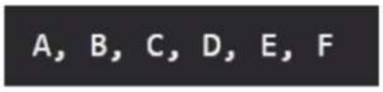
- BFS needs lots of time if solution far.

DFS(Depth First Search)

- DFS stands for Depth First Search.
- In DFS traversal, the stack data structure is used, which works on the LIFO principle.
- In DFS, traversing can be started from any node, or we can say that any node can be considered as a root node until the root node is not mentioned in the problem.



```
Input:
          A
         / \
        B   D
       /   / \
      C   E   F
```



```
A, B, C, D, E, F
```

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DFS(Depth First Search)

Advantage

- It takes less time to reach to the goal node.

Disadvantage

- It goes for deep down and sometimes in infinite loop.

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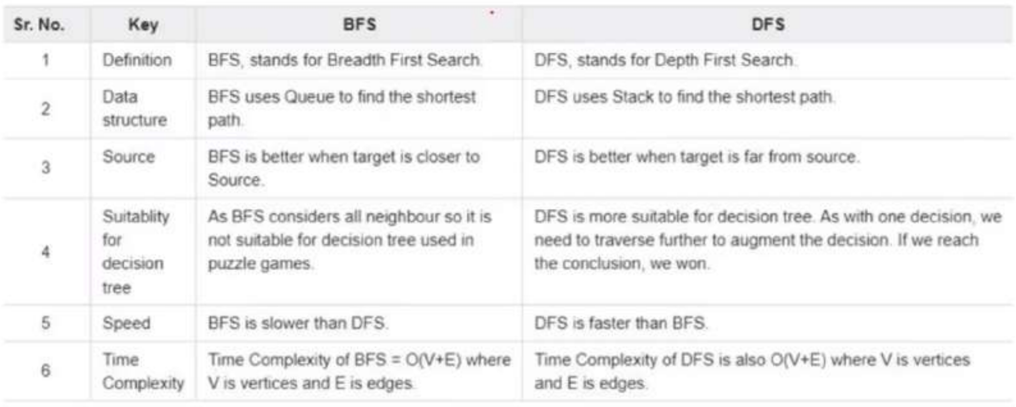
BFS(Breadth First Search)



Sr. No.	Key	BFS	DFS
1	Definition	BFS, stands for Breadth First Search.	DFS, stands for Depth First Search.
2	Data structure	BFS uses Queue to find the shortest path.	DFS uses Stack to find the shortest path.
3	Source	BFS is better when target is closer to Source.	DFS is better when target is far from source.
4	Suitablity for decision tree	As BFS considers all neighbour so it is not suitable for decision tree used in puzzle games.	DFS is more suitable for decision tree. As with one decision, we need to traverse further to augment the decision. If we reach the conclusion, we won.
5	Speed	BFS is slower than DFS.	DFS is faster than BFS.
6	Time Complexity	Time Complexity of BFS = O(V+E) where V is vertices and E is edges.	Time Complexity of DFS is also O(V+E) where V is vertices and E is edges.

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Heuristic Function

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Heuristic Function

- 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.
- Not always give the best solution, but it guaranteed to find a good solution in reasonable time.
- It estimates how close a state is to the goal.
- Represented by h(n).
- The value of the heuristic function is always positive.

$$h(n) <= h^*(n)$$

Here h(n) is heuristic cost, and h*(n) is the estimated cost. Hence heuristic cost should be less than or equal to the estimated cost.

- Best First Search Algorithm(Greedy search)
- A* Search Algorithm

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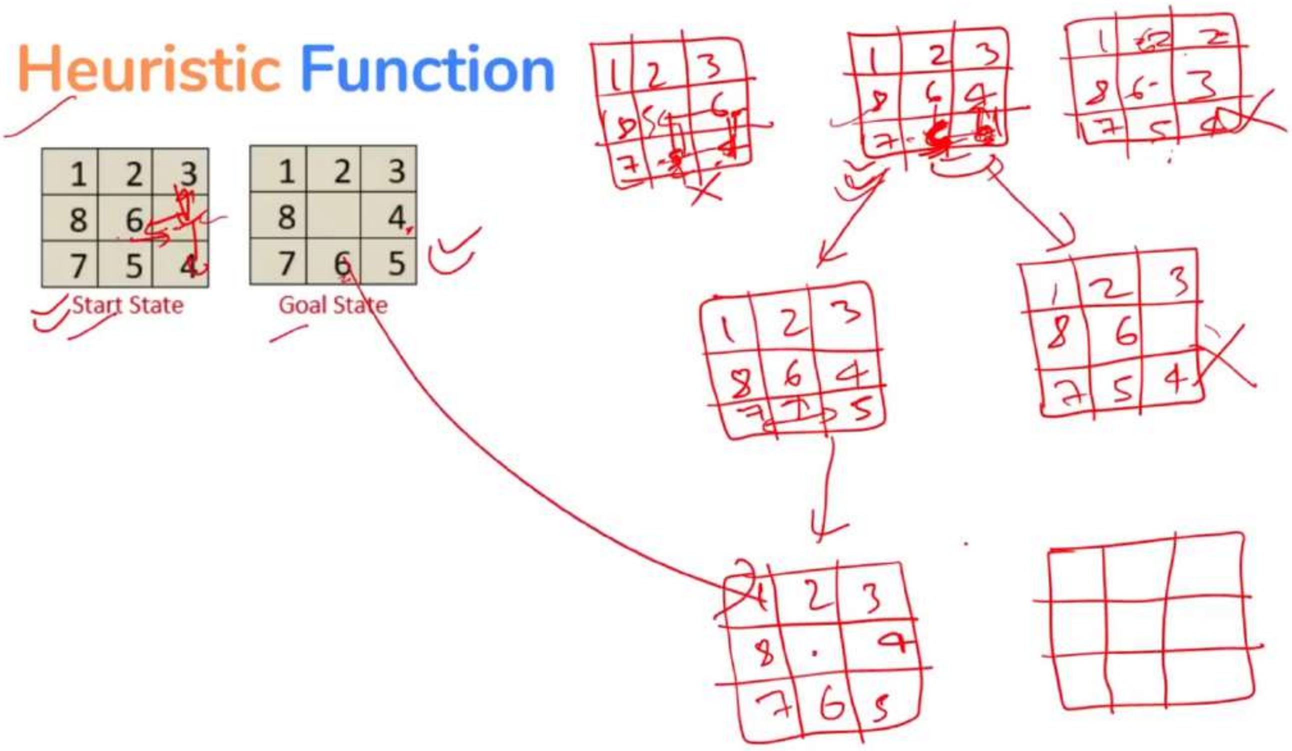
Heuristic Function



Heuristic Function

•**Blind search →** traversing the search space until the goal nodes is found (might be doing exhaustive search).

•*Techniques* : **Breadth First Uniform Cost ,Depth first, Interactive Deepening search.**

•Guarantees solution.

•**Heuristic search →** search process takes place by traversing search space with applied rules (information).

•*Techniques*: **Greedy Best First Search, A* Algorithm**

•There is no guarantee that solution is found.

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Heuristic Function

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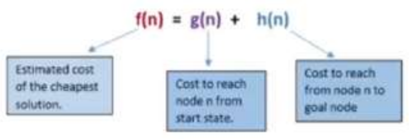
Heuristic Function

- A* search is the most commonly known form of best-first search.
- It uses heuristic function h(n), and cost to reach the node n from the start state g(n).
- It has combined features of UCS and greedy best-first search, by which it solve the problem efficiently.
- A* search algorithm finds the shortest path through the search space using the heuristic function.
- This search algorithm expands less search tree and provides optimal result faster.


f(n) = g(n) + h(n)
Estimated cost of the cheapest solution.
Cost to reach node n from start state.
Cost to reach from node n to goal node

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Heuristic Function

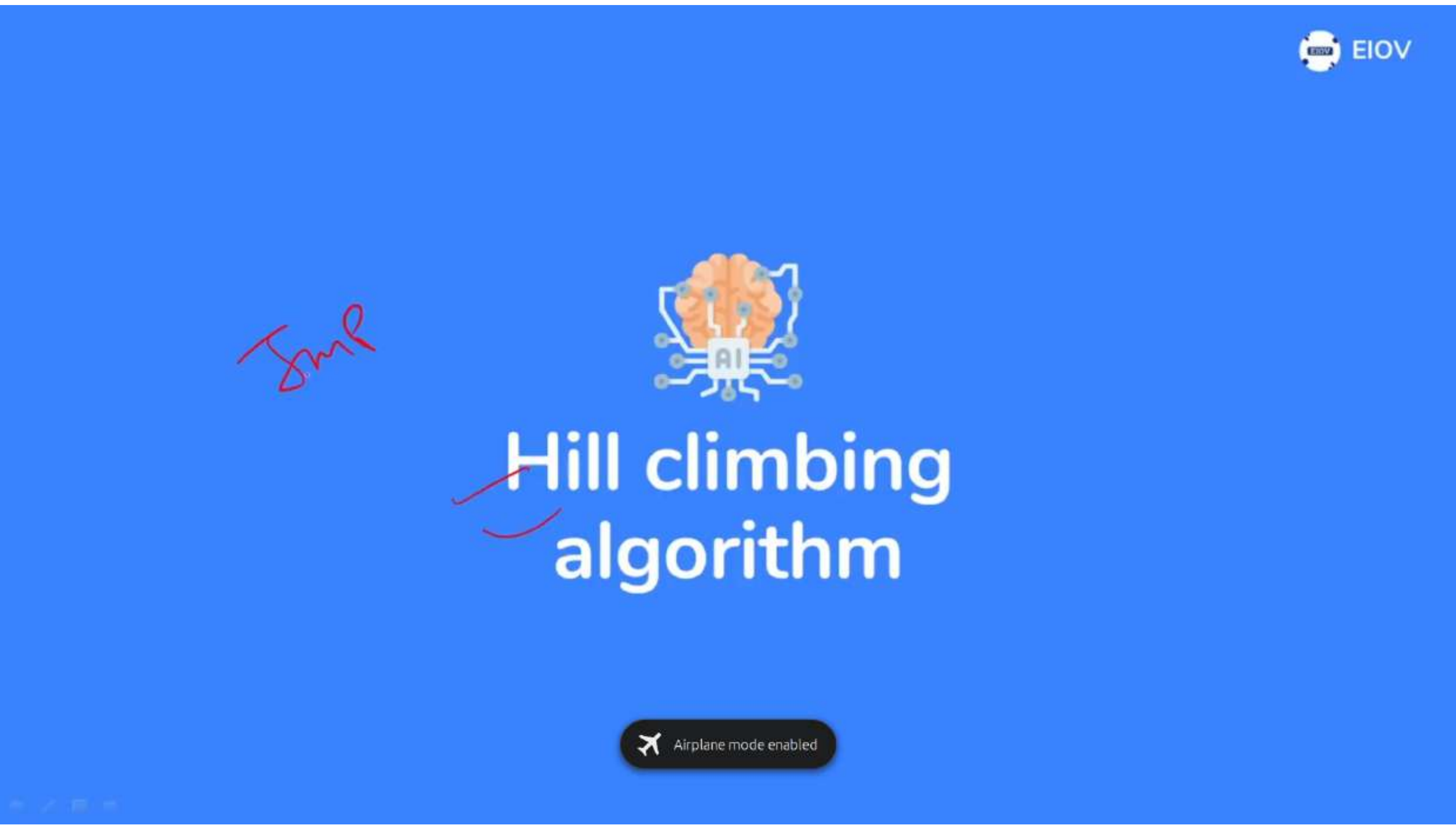
- **Example**

watch Previous example of dice in A* Alog

watch searching video

~~वीडियो देखो~~

A*



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Hill climbing algorithm

Airplane mode enabled

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Hill climbing algorithm Concept

- It is a local search algorithm which continuously moves in the direction of increasing value to find the peak of the mountain.
- It terminates when it reaches a peak value where no neighbor has a higher value.
- **Example:** Traveling-salesman Problem in which we need to minimize the distance traveled by the salesman.
- Also called greedy local search.
- A node of hill climbing algorithm has two components which are state and value.

Features:

- **Greedy approach:** Hill-climbing algorithm search moves in the direction which optimizes the cost.
- **No backtracking:** It does not backtrack the search space, as it does not remember the previous states.

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Hill climbing algorithm

- **Step 1:** Evaluate the initial state, if it is goal state then return success and Stop.
- **Step 2:** Loop Until a solution is found or there is no new operator left to apply.
- **Step 3:** Select and apply an operator to the current state.
- **Step 4:** Check new state:
  - If it is goal state, then return success and quit.
  - Else if it is better than the current state then assign new state as a current state.
  - Else if not better than the current state, then return to step2.
- **Step 5:** Exit.

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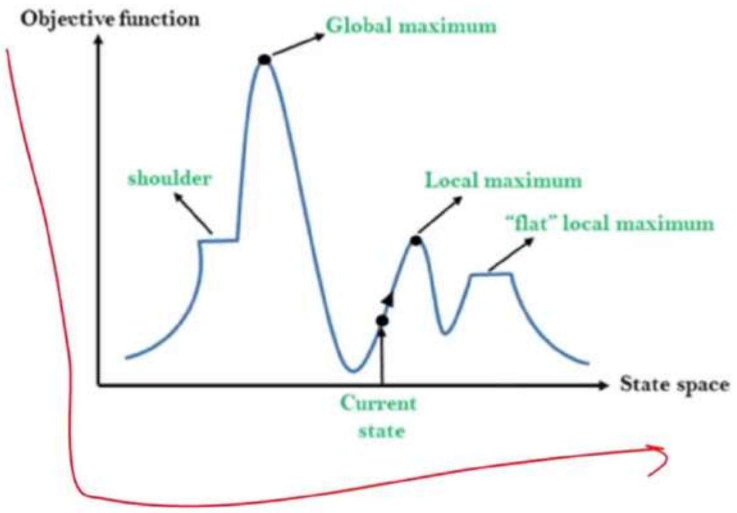
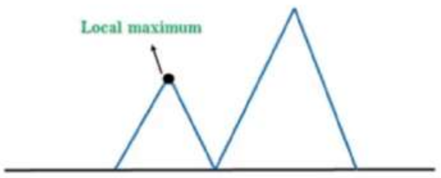
Hill climbing algorithm



Drawbacks and Solution

1. Local Maximum:

- A local maximum is a peak state in the landscape which is better than each of its neighboring states, but there is another state also present which is higher than the local maximum.



Solution:

- Backtracking technique can be a solution of the local maximum in state space landscape.

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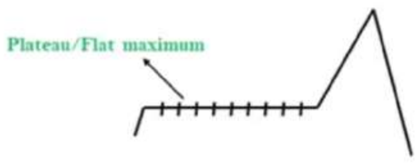
Drawbacks and Solution

2. Plateau:

- A plateau is the flat area of the search space in which all the neighbor states of the current state contains the same value, because of this algorithm does not find any best direction to move.



Solution:

- Take big steps or very little steps while searching.

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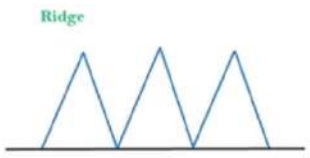
Drawbacks and Solution

3. Ridge:

- A ridge is a special form of the local maximum. It has an area which is higher than its surrounding areas, but itself has a slope, and cannot be reached in a single move.



Solution:

- With the use of bidirectional search.

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Water jug problem

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Water jug problem

"You are given two jugs, a 4-liter one and a 3-liter one. Neither has any measuring markers on it. There is a pump that can be used to fill the jugs with water. How can you get exactly 2 liters of water into a 4-liter jug."

State: (x, y)
where x represents the quantity of water in a 4-liter jug and y represents the quantity of water in a 3-liter jug.
That is, x = 0, 1, 2, 3, or 4 y = 0, 1, 2, 3
Start state: (0, 0).
Goal state: (2, n) for any n.

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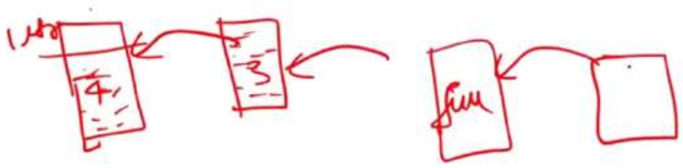
Water jug problem



1	(x, y) is X<4 ->(4, Y)	Fill the 4-liter jug
2	(x, y) if Y<3 -> (x, 3)	Fill the 3-liter jug
3	(x, y) if x>0 -> (x-d, d)	Pour some water out of the 4-liter jug.
4	(x, y) if Y>0 -> (d, y-d)	Pour some water out of the 3-liter jug.
5	(x, y) if x>0 -> (0, y)	Empty the 4-liter jug on the ground
6	(x, y) if y>0 -> (x,0)	Empty the 3-liter jug on the ground
7	(x, y) if X+Y >= 4 and y>0 -> (4, y-(4-x))	Pour water from the 3-liter jug into the 4-liter jug until the 4-liter jug is full

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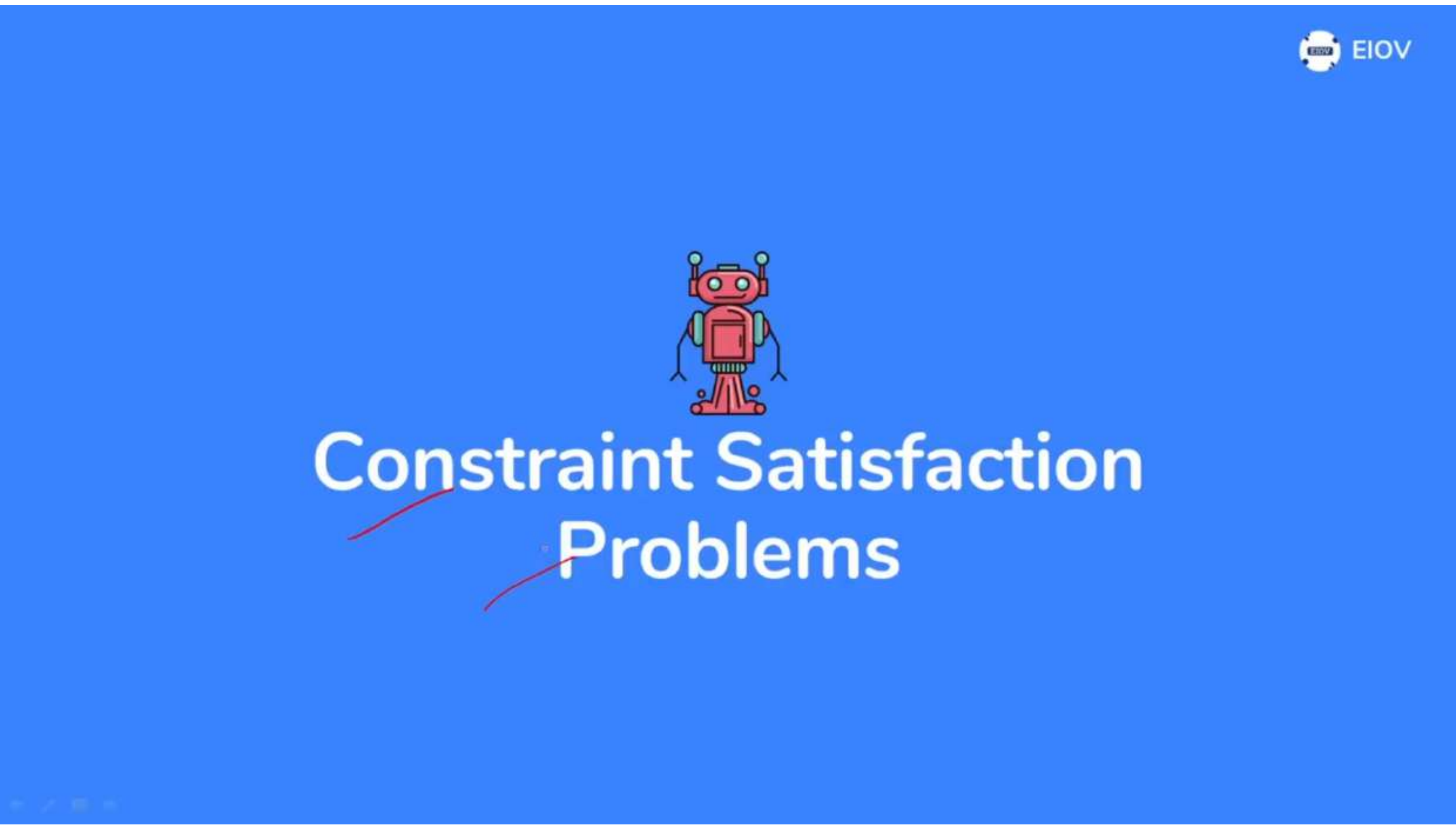
Water jug problem

8	(x, y) if X+Y>=3 and x>0 -> (x-(3-y), 3))	Pour water from the 4-liter jug into the 3-liter jug until the 3-liter jug is full.
9	(x, y) if X+Y <=4 and y>0 -> (x+y, 0)	Pour all the water from the 3-liter jug into the 4-liter jug.
10	(x, y) if X+Y<=3 and x>0 -> (0, x+y)	Pour all the water from the 4-liter jug into the 3-liter jug.
11	(0, 2) -> (2, 0)	Pour the 2-liter water from the 3-liter jug into the 4-liter jug.
12	(2, Y) -> (0, y)	Empty the 2-liter in the 4-liter jug on the ground.



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Constraint Satisfaction Problems

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Constraint Satisfaction Problems

Constraint satisfaction is the process of finding a solution through a set of constraints that impose conditions that the variables must satisfy.

- Consider a Sudoku game with some numbers filled initially in some squares.
- You are expected to fill the empty squares with numbers ranging from 1 to 9 in such a way that no row, column or a block has a number repeating itself.
- This is a very basic constraint satisfaction problem.
- You are supposed to solve a problem keeping in mind some constraints.
- The remaining squares that are to be filled are known as variables, and the range of numbers (1-9) that can fill them is known as a domain.
- Variables take on values from the domain.
- The conditions governing how a variable will choose its domain are known as constraints.

Constraint Satisfaction Problems

A constraint satisfaction problem (CSP) is a problem that requires its solution within some limitations or conditions also known as constraints. It consists of the following:

- A finite set of **variables** which stores the solution (V = {V1, V2, V3,....., Vn})
- A set of **discrete** values known as **domain** from which the solution is picked (D = {D1, D2, D3,.....,Dn})
- A finite set of **constraints** (C = {C1, C2, C3,......, Cn})

Suppose that a row, column and block already have 3, 5 and 7 filled in. Then the domain for all the variables in that row, column and block will be {1, 2, 4, 6, 8, 9}.

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Constraint Satisfaction Problems

The following problems are some of the popular problems that can be solved using CSP:

1. CryptArithmetic
2. n-Queen
3. Map Coloring
4. Crossword
5. Sudoku
6. Latin Square Problem

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CSP CryptArithmetic

Types: CSP

Constraints:

- The result should satisfy the predefined arithmetic rules, i.e., 2+2 =4, nothing else.
- Digits should be from **0-9** only.
- The problem can be solved from both sides, i.e., **L.H.S, or R.H.S.**

Example 1:

```
   TO          (2)   (1)
 + GO    +  (8) ~~9~~  (1)
 ----    ------------------
  OUT    (1)  (0) ~~1~~  (2)
 ↓
 (1)
```

```
      7 2        2+2 ⇒ (9)
  +   4 1        2+8 = 10
  -------        --------
    1 1 3        2+9 = (11)
```

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CSP CryptArithmetic

Example 2:

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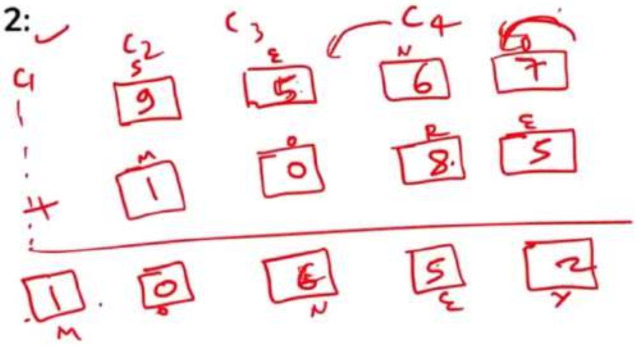
```
 SEND
+MORE
MONEY
```



$5+1 = 0 \rightarrow \boxed{1} \rightarrow c$

$8+1 = 9$

$9+1 = \boxed{0}$

$E + 0 = N$

$N + R = E$

$6 + 8 = 5$

$6 + 9 = 15 = \boxed{14}$

$\boxed{15}$

$D + E = Y$

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Backtracking

- In artificial intelligence, backtracking is often used in search algorithms to explore the search space and find a solution to a problem.
- It involves trying a set of possible choices, and if a choice leads to a dead end or a solution cannot be found, then backtracking to the previous step and trying a different choice.
- Backtracking algorithms are typically used when the solution to a problem cannot be determined in advance and needs to be discovered through trial and error.
- **For example**
  - Backtracking can be used in constraint satisfaction problems, where variables are subject to constraints, and a value must be found for each variable that satisfies all of the constraints. In this case, the algorithm would try different values for each variable and backtrack if it determines that a particular value does not satisfy the constraints.

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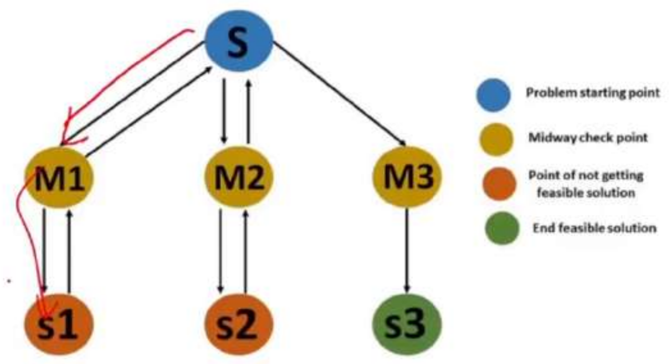
Backtracking



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Game playing good candidate

Game playing is a good candidate for artificial intelligence (AI) because it involves many of the challenges that AI systems are designed to tackle. Games often require decision-making, problem-solving, and strategy, which are all areas where AI can excel.
Some specific reasons why game playing is a good candidate for AI include:

1. Games have well-defined rules and objectives: The rules of a game provide a clear framework for AI systems to operate within. This makes it easier to design algorithms and evaluate their performance.
2. Games provide a controlled environment: In a game, the AI system knows all the rules and has access to all the information it needs to make decisions. This makes it easier to design and test AI algorithms, as compared to more open-ended environments where the AI may need to handle unexpected events or incomplete information.
3. Games offer a rich source of data: Games provide a large amount of data that can be used to train and evaluate AI algorithms. For example, chess has been used extensively to test AI algorithms because it provides a large number of well-defined positions that can be used to train and evaluate the algorithms.

Min-Max Procedure

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Min-Max Algorithm

- Mini-max algorithm is a recursive or backtracking algorithm which is used in decision-making and game theory.
- Mini-Max algorithm uses recursion to search through the game-tree.
- Min-Max algorithm is mostly used for game playing in AI. Such as Chess, Checkers, tic-tac-toe, go, and various tow-players game. This Algorithm computes the minimax decision for the current state.
- In this algorithm two players play the game, one is called MAX and other is called MIN.
- Both the players fight it as the opponent player gets the minimum benefit while they get the maximum benefit.
- Both Players of the game are opponent of each other, where MAX will select the maximized value and MIN will select the minimized value.
- The minimax algorithm performs a depth-first search algorithm for the exploration of the complete game tree.
- The minimax algorithm proceeds all the way down to the terminal node of the tree, then backtrack the tree as the recursion.

Properties Min-Max Algorithm

- **Complete**- Min-Max algorithm is Complete. It will definitely find a solution (if exist), in the finite search tree.
- **Optimal**- Min-Max algorithm is optimal if both opponents are playing optimally.
- **Time complexity**- O(bm), where b is branching factor of the game-tree, and m is the maximum depth of the tree.
- **Space Complexity**- O(bm).

Limitation of the minimax Algorithm:

The main drawback of the minimax algorithm is that it gets really slow for complex games such as Chess, go, etc.

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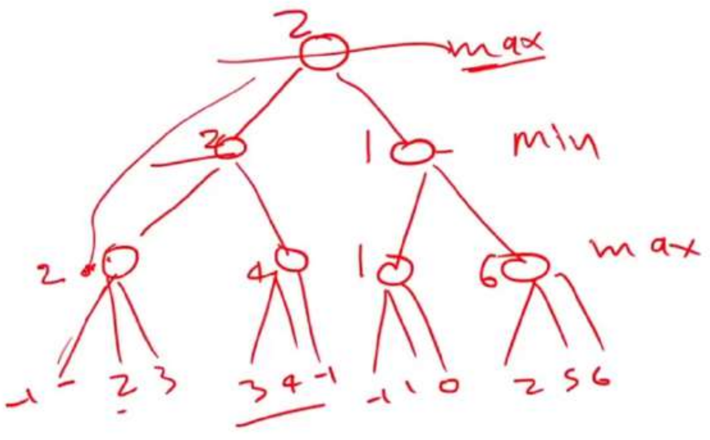
Properties Min-Max Algorithm

- **Example 1:**



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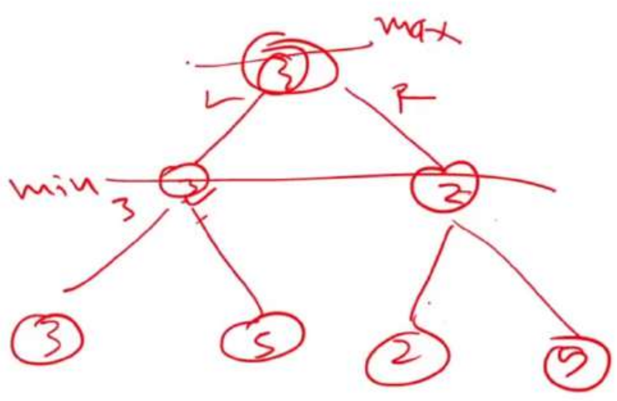
Properties Min-Max Algorithm

- **Example 2:**



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Alpha-beta pruning

- Alpha-beta pruning is a modified version of the minimax algorithm.
- It is an optimization technique for the minimax algorithm.
- There is a technique by which without checking each node of the game tree we can compute the correct minimax decision, and this technique is called **pruning**.
- This involves two threshold parameter Alpha and beta for future expansion, so it is called **alpha-beta pruning**.
- It is also called as **Alpha-Beta Algorithm**.
  - **Alpha**: The best (highest-value). The initial value of alpha is -∞.
  - **Beta**: The best (lowest-value). The initial value of beta is +∞.
- **Condition:**
  - $\alpha >= \beta$
- **Key points:**
  - The Max player will only update the value of alpha.
  - The Min player will only update the value of beta.
  - We will only pass the alpha, beta values to the child nodes.

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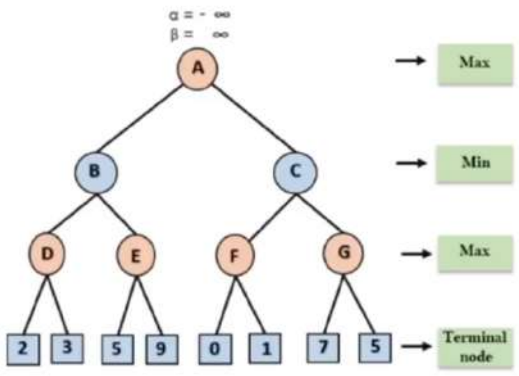
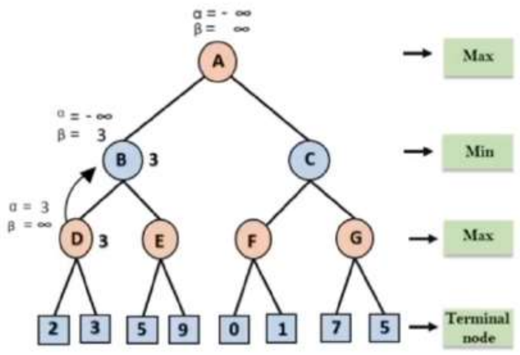
Alpha-beta pruning





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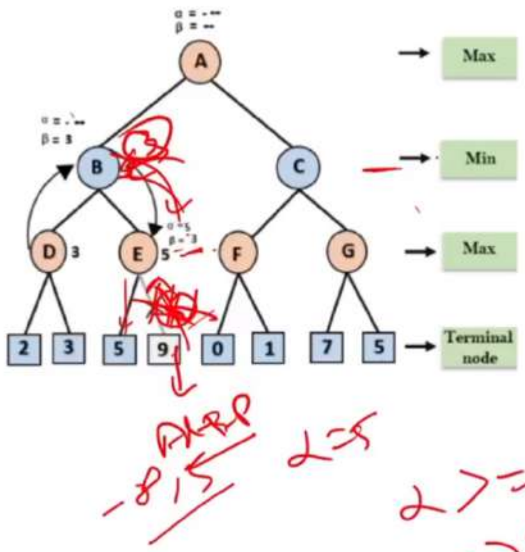
Alpha-beta pruning



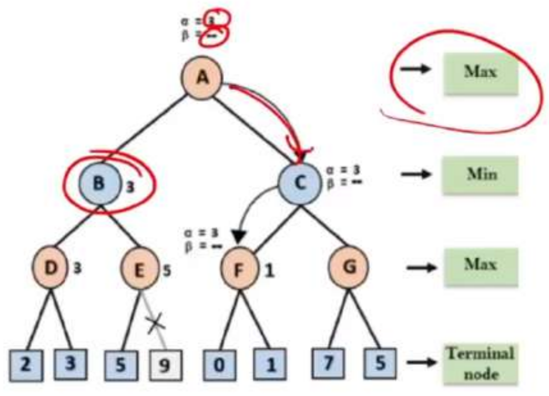
$-\infty, 5$

$\alpha = 5$

$\alpha >= \beta$

$5 >= 3$

$-\infty, 3$



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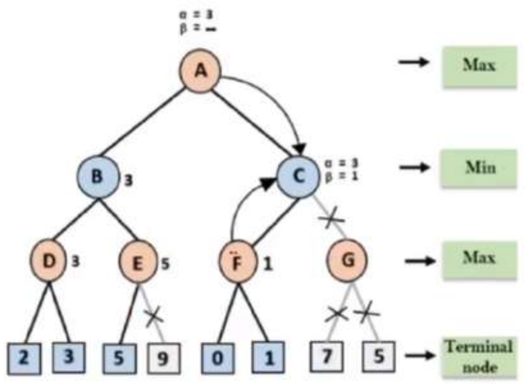
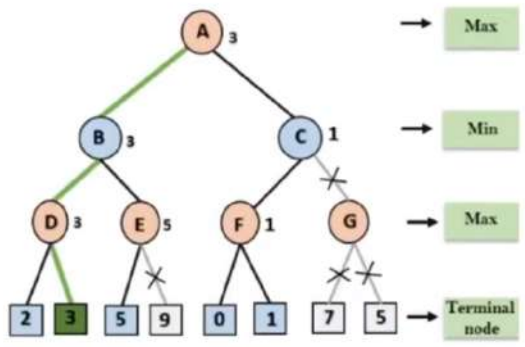
Alpha-beta pruning





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NLU vs NLG

Natural language understanding

Natural language Generation

NLU	NLG
NLU is the process of reading and interpreting language.	NLG is the process of writing or generating language.
It produces non-linguistic outputs from natural language inputs.	It produces constructing natural language outputs from non-linguistic inputs.

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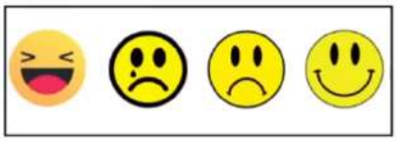
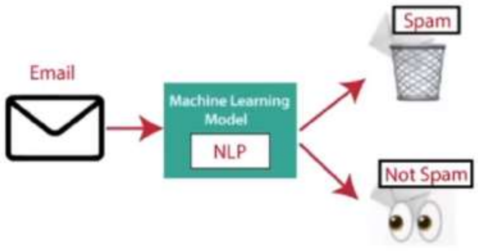
Applications of NLP

- Machine Translation
- Sentiment analysis
- Spelling correction
- Spam Detection
- Speech Recognition
- Chatbot





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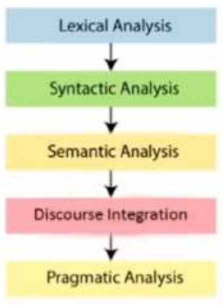
Role of NLP and Phases

- NLP help to communicate with intelligent system.
- Helps to control computer with voice commands.
- Helps human to communicate with machines.

- **Phases:**
  - Lexical Analysis
  - Syntactic Analysis
  - Semantic Analysis
  - Discourse Integration
  - Pragmatic Analysis



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int main(){

}

Phases

1. Lexical Analysis:

- This is the first phase of NLP. This phase scans the source code as a stream of characters and converts it into meaningful lexemes. It divides the whole text into paragraphs, sentences, and words.

2. Syntactic Analysis:

- It is used to check grammar, word arrangements, and shows the relationship among the words.
- **Example:** Mumbai goes to the Delhi.
- In the real world, Agra goes to the Poonam, does not make any sense, so this sentence is rejected by the Syntactic analyzer.

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Phases

3. Semantic Analysis:

- Concerned with the meaning representation. It mainly focuses on the literal meaning of words, phrases, and sentences.

4. Discourse Integration:

- It depends upon the sentences that proceeds it and also invokes the meaning of the sentences that follow it.

5. Pragmatic Analysis:

- Pragmatic is the fifth and last phase of NLP. It helps you to discover the intended effect by applying a set of rules that characterize cooperative dialogues.
- **For Example:** "Open the door" is interpreted as a request instead of an order.

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Machine translation

- Machine translation is the process of using artificial intelligence to automatically translate text from one language to another without ~~human involvement~~.
- Modern machine translation goes beyond simple word-to-word translation to communicate the full meaning of the original language text in the target language.

- **Types of MT Systems:**
  - Bilingual MT System
  - Multilingual MT System

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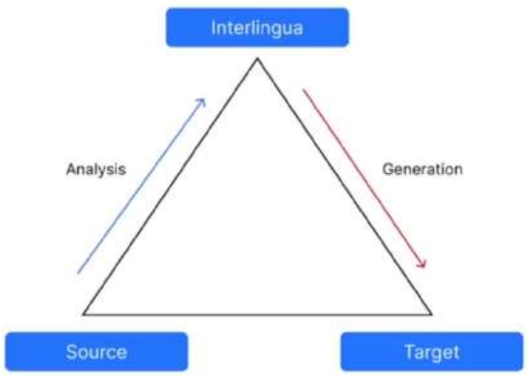
Approaches Machine translation

- Direct MT Approach
- Interlingua Approach
- Transfer Approach
- Empirical MT Approach



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Approaches Machine translation

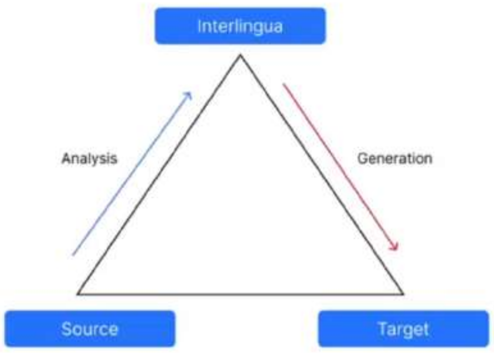
SL → Source Language
TL → Target Language

Direct MT Approach:

- It is less popular but the oldest approach of MT.
- SL to TL(directly).

Interlingua Approach:

- SL to IL called Interlingua
- Then translate IL to TL.



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Approaches Machine translation

Transfer Approach:

- 1st----> SL texts to abstract SL-oriented representations.
- 2nd---> SL-oriented representations to equivalent TL-oriented representations.
- 3rd----> Final text is generated.

Empirical MT Approach:

- This is an emerging approach for MT.
- It uses large amount of data.
- Raw data consists of the text and their translations.
- Analogy-based, example-based, memory machine translation techniques use empirical MT approach.

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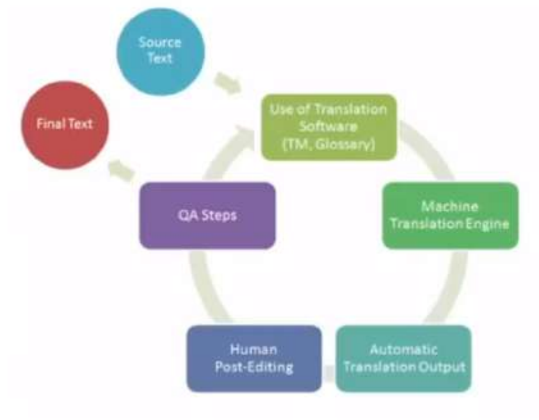
Process of Machine translation


Source Text
Use of Translation Software (TM, Glossary)
Machine Translation Engine
Automatic Translation Output
Human Post-Editing
QA Steps
Final Text

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Speech recognition

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Speech recognition

- Speech recognition speech recognition is the process that enables a computer to recognize and responds to its spoken words and then convert them in a format that the machine understands.
- Speech recognition is widely used in digital assistants, smart speaker, smart homes and automation for a variety of services, products and solutions.

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Algorithms for Speech recognition

- **Natural language processing(NLP)**

- **Hidden Markov models**
  - Markov chain model is useful for observable events such as text inputs.
  - Hidden Markov models allow us to incorporate hidden events, such as part of speech tags into a probabilistic model.

- **Neural networks**
  - A neural network is a series of algorithms that endeavors to recognize underlying relationships in a set of data through a process that mimics the way the human brain operates.
  - In this sense, neural networks refer to systems of neurons, either organic or artificial in nature.

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Applications of Speech recognition

- Automotive
- Technology
- Healthcare
- Sale
- Security

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Robot

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Robot

- Robot are the artificial agents acting in real world environment.
- Robots are aimed at manipulating the objects by perceiving moving and doing repetitive functions without getting bored, distracted.

Robotics

- Robotics is a branch of AI which is composed of electrical engineering, mechanical engineering and computer science for designing, construction and application of robots.

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Components of Robot

- Power supply
- Actuators
- Electric motors (AC/DC)
- Pneumatic air muscles
- Muscle wires
- Piezo Motors and ultrasonic motors
- Sensors.

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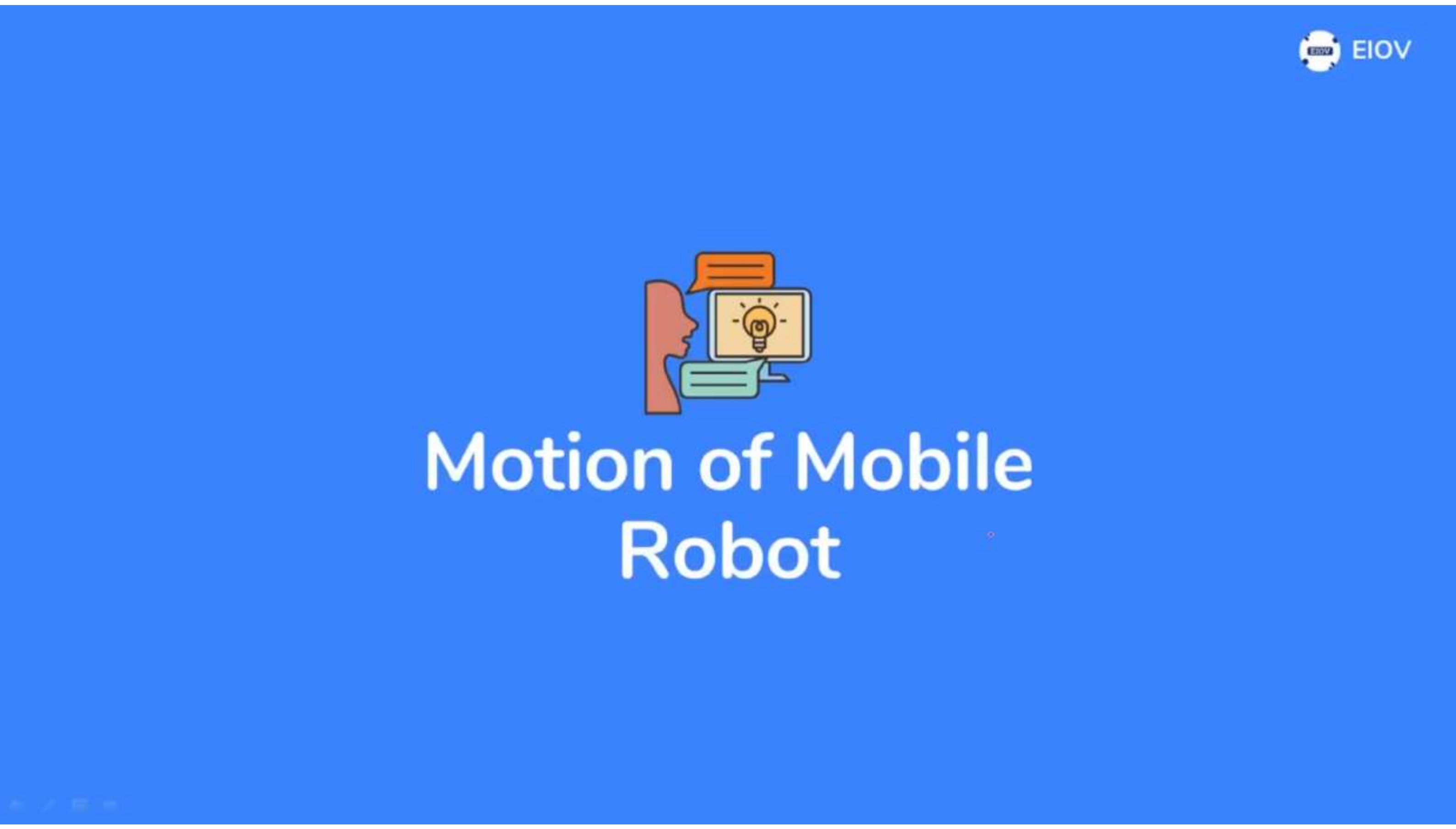
Robot Locomotion and Types

- Locomotion is the mechanism that makes a robot capable of moving in its environment.

- **There are various types of locomotion:**
  - 1. Legged the locomotion
  - 2. Wheeled the locomotion
  - 3. Slip locomotion



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Motion of Mobile Robot

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Motion of Mobile Robot

- **Terrestrial:**
  - Terrestrial robots move on the ground.
  - Wheeled robots are most common type of robots in this category.
- **Airborne**
  - Robotic helicopters, robotically controlled parachutes have been deployed.
- **Aquatic**
  - This type of robots operates in water, either at the surface or underwater.
- **Space**
  - Robots are designed to operate in the microgravity of outer space, typically for space station maintenance.

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1. Logic based agent

- An agent can represents the knowledge of its world, its goals and the current situation.
- Logical agent has a collection of sentences in logic.
- What to do with the help of logical sentences.
- Knowledge and reasoning are important.

Advantage:
- It have a clean semantic due to which they can be used over long period of time.

Disadvantage:
- It creates issues with complex, dynamic environments.

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Reactive agent

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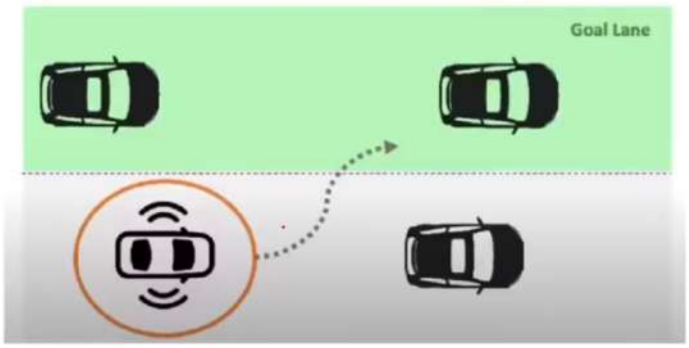
2. Reactive agent

- The reactive agent architecture are sometime referred toa as behavioral, situated. and reactive.
- It is referred to as reactive because search systems are 100% understood to be just reacting to an environment without reasoning about it.



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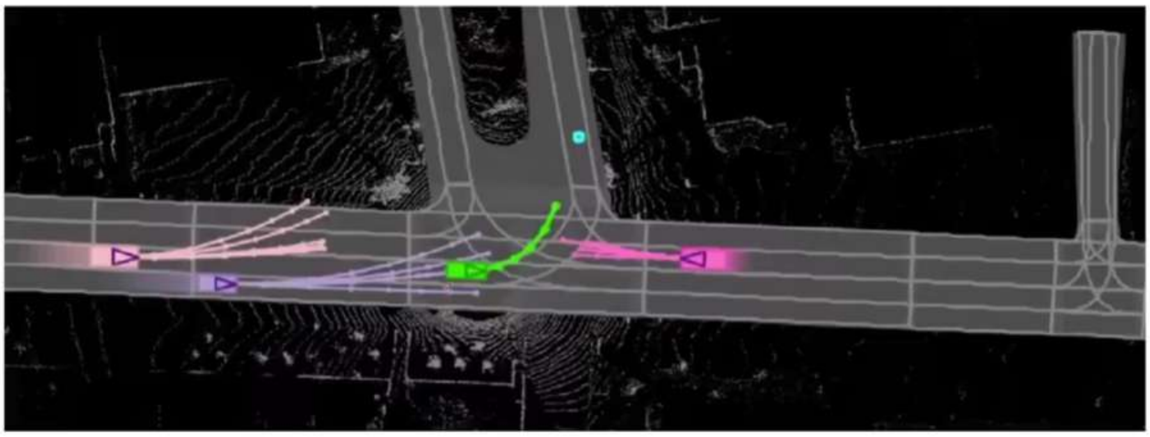
2. Reactive agent



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Belief-Desire-Intension agent

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3. Belief-Desire-Intension agent

- The BDI agent architecture is based on Michael Bratman's philosophical theory (Bratman 1987) that explains reasoning through the following attitudes: beliefs, desires and intentions.

Beliefs are the agent's model of the environment, basically what it believes to be true. It's not knowledge as some of its beliefs might be false.

Desires represent the ideal state of the environment for the agent. Like in the human mind, these represent things we would like to see accomplished in the future. A desire might be realistic or not, as it occurs with human thinking, and may or may not be achievable.

Intentions represent a subset of desires that the agent has taken as goals to be accomplished soon.

Belief represents the agent's model of the world, desire represents the agent's goal(s) and intention represents the action choice.

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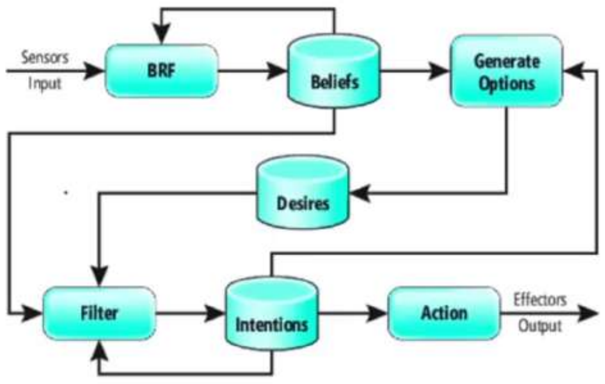
3. Belief-Desire-Intension agent

Robotic Process Automation (RPA) application—specifically, a Travel Assistant Agent.



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3. Belief-Desire-Intension agent

- **Advantages**
  - It uses a standard human reasoning process to reach to goal it is easy to understand.
  - It has clear functional decomposition.

- **Disadvantage**
  - Difficulty lies in knowing how to efficiently implement all BDI model functions.

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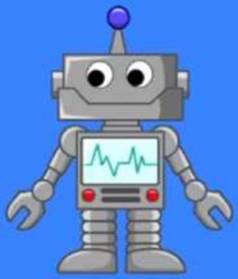

Agent communication

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Multiagent and Agent communication

- While acting in real world and agent may not be always in Singleton mode.
- It has to deal with the situation wherein other agents and related factors are affecting the agents environment.
- Such systems wherein multiple agent work together, communicate, co-operate and deal with the situation are termed as multi agent system .
- Multi agent system are essentially distributed systems which more efficient in the sense that they can be optimized and are mostly easier to understand and easier to develop especially when the problem being solved is itself distributed.
- Data and information itself is distributed is spinning at different geographical locations and needs to be handled through multiple agents.
- Data can come from various domains and multiple devices or components are involved in data generation.
- The system itself is too big and complex that needs to be separated in multiple components so as to reduce its complexity and size that can be handled easily.

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Multiagent system and characteristics

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Multiagent system characteristics

- Each agent has just incomplete information and is restricted in its capabilities.
- The system control is distributed.
- Data is decentralized.
- Computation is asynchronous.
- multi agent environments are typically open and have no centralized design.
- Multi agent environments have agents that are autonomous and distributed and maybe self interested.

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Negotiation and Bargaining

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बातचीत सौदेबाजी

Negotiation and Bargaining

- **Negotiation:** discussions at which people try to decide or agree something.
- **Bargaining:** to discuss prices, conditions, etc. with somebody in order to reach an agreement that suits each person

- In a multi agent system negotiation is form of interaction that occurs among agents with different goals.
- Major challenges of negotiation and bargaining is to allocate is scars resources scarce resources among agents representing self interested parties the resources can be bandwidth commodities money processing power etc. The resource becomes scarce as competing claims for it can be simultaneously satisfied.
- Negotiation and bargaining is a process by which a joint decision is reached by two or more agents each trying to reach an individual goals or objective.

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Negotiation and Bargaining

- Negotiation and bargaining mechanism should have the following attributes:
  - Efficiency
  - stability
  - simplicity
  - distribution
  - symmetry

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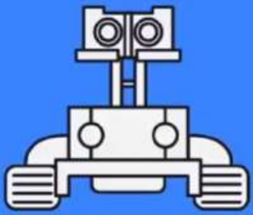

Trust and Reputation in Multiagent system

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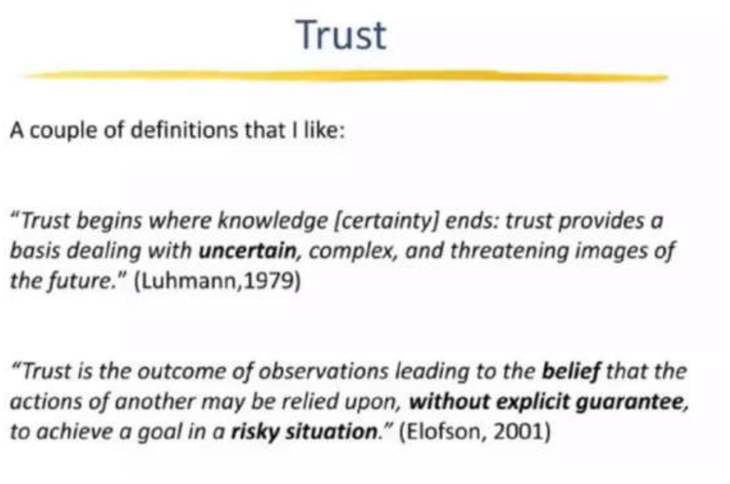
Trust and Reputation in Multiagent system

Trust = if your car broke then
your are trying
to get help from stanger then you
have trust on it



Trust

A couple of definitions that I like:

"Trust begins where knowledge [certainty] ends: trust provides a basis dealing with ***uncertain****, complex, and threatening images of the future."* (Luhmann,1979)

"Trust is the outcome of observations leading to the ***belief*** *that the actions of another may be relied upon,* ***without explicit guarantee****, to achieve a goal in a* ***risky situation****."* (Elofson, 2001)

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Trust and Reputation in Multiagent system

Reputation

"After death, a tiger leaves behind his skin, a man his reputation"

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Trust and Reputation in Multiagent system

What is reputation good for?

- Reputation is one of the elements that allows us to **build trust**.
- Reputation has also a social dimension. It is not only useful for the individual but also for the society as a mechanism for **social order**.

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Trust and Reputation in Multiagent system

- TMS is designed to ensure the integrity of an agent's knowledge, which should be stable, well founded and logically consistent.
- In a multi agent system, a group of agents can form a small society in which they play different kinds of role. The group defines the rules and the rules define the commitments associated with them.
- When an agent joins a group, he joins in one or more roles and acquires the commitments of the role.