

Artificial Intelligence

[John McCarthy]

- Artificial intelligence is composed of two words **Artificial** and **Intelligence**
 - ↓
 - "Man-made"
 - ↓
 - "thinking power"
- It is a branch of Computer science by which we can create intelligent machine which we can behave like a human, think like humans, and able to make decision.

⇒ When AI exist

→ When a machine can have human based skills such as learning, reasoning and solving problems.

⇒ Why we learn AI

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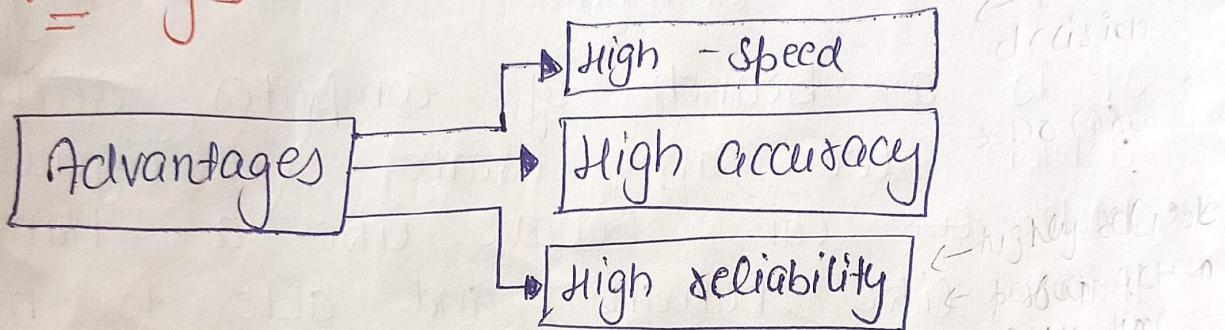
- With the help of AI, we can create such software which can solve real-world problems.
- Can create personal virtual assistant.
- Can build such robots.

Develop Code and perform task.

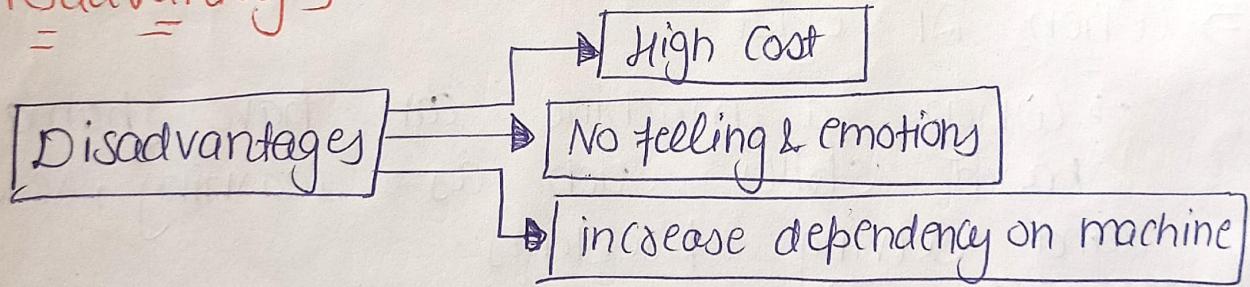
Goals

- Solve knowledge - intensive tasks
- Replicate human intelligence
- Build a machine which can perform tasks that require human intelligence
 - Proving a theorem
 - Playing chess
 - Driving a car in traffic

Advantages



Disadvantages



Importance

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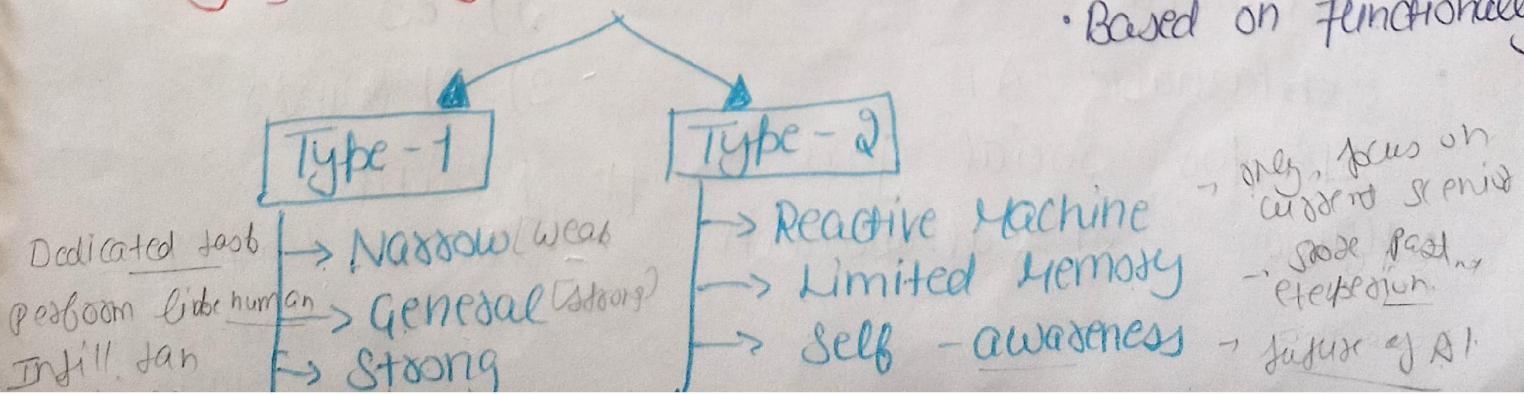
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- Reasoning [logic, rule]
- Branching [choosing different paths]
- Selection [" " option] based on certain condⁿ
- Reduce human effort ↑ efficiency
- Looping or repeating [loop when job is done]
- Learning → Supervised learning
→ Unsupervised learning
- Facial recognitions → verify identity

Application of AI

- It is becoming essential for today's time because it can solve complex problems.
- AI in astronomy: It can useful to solve complex universe problems.
help for technology → how is world origin
- AI in Healthcare: AI can help doctors with diagnoses, can inform when patients are worsening.
= automatic
- AI in Gaming: AI Machine can play strategic games like chess,
- AI in finance: machine learning into financial process. → trading
- AI in education:
= problem solving
= test video AI chatbot can communicate with student as a teaching assistant
- AI in E-commerce: AI is providing a competitive edge to the e-commerce industry. help shoppers to discover associated product with colors etc.
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- AI in Robotics → smart tooling. (Automated Industry)
→ self-driving cars
- AI in Agriculture

Types of AI



History of AI

- Maturation of Artificial intelligence [1943 - 1952]
- The birth of Artificial intelligence [1952 - 1956]
- The golden year - Early enthusiasm [1956 - 1974]
- The first AI winter [1974 - 1980]
- A boom of AI [1980 - 1987] *Copyrighted by Codelab.io
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- The second winter [1987 - 1993]
- The emergence of intelligent agents [1993 - 2011]
- Deep learning, big data. [2011 - present]

Future of AI

- Advanced Machine learning Technique.
- Explainable AI
- AI for Social good.
- Human - AI Collaboration.

Past of AI

- 1) Origin [1950]
- 2) ES
- 3) AI Winter

Present

- Machine learning
- Big data and Deep

#Intelligence

- It refers to the ability of machines to learn, reason and solve problems.
- A Mechanism which
 - a) stimulates
 - action
 - further thought
 - b) is triggered by
 - external stimulus
 - internal stimulus
 - c) acts through
 - present environment
 - past memory

#knowledge

→ awareness and understanding of objects, data and situation from experience

- It refers to the information and understanding that a system possesses about the world.
- knowledge is a crucial component of AI.
- It means to have some information saved in memory from the prior experience of something like any skills, object or facts.

⇒ approaches of knowledge representation:
logical representation.
Semantic network
through nodes & links

Study of way how knowledge is actually picturized.

⇒ Type of knowledge

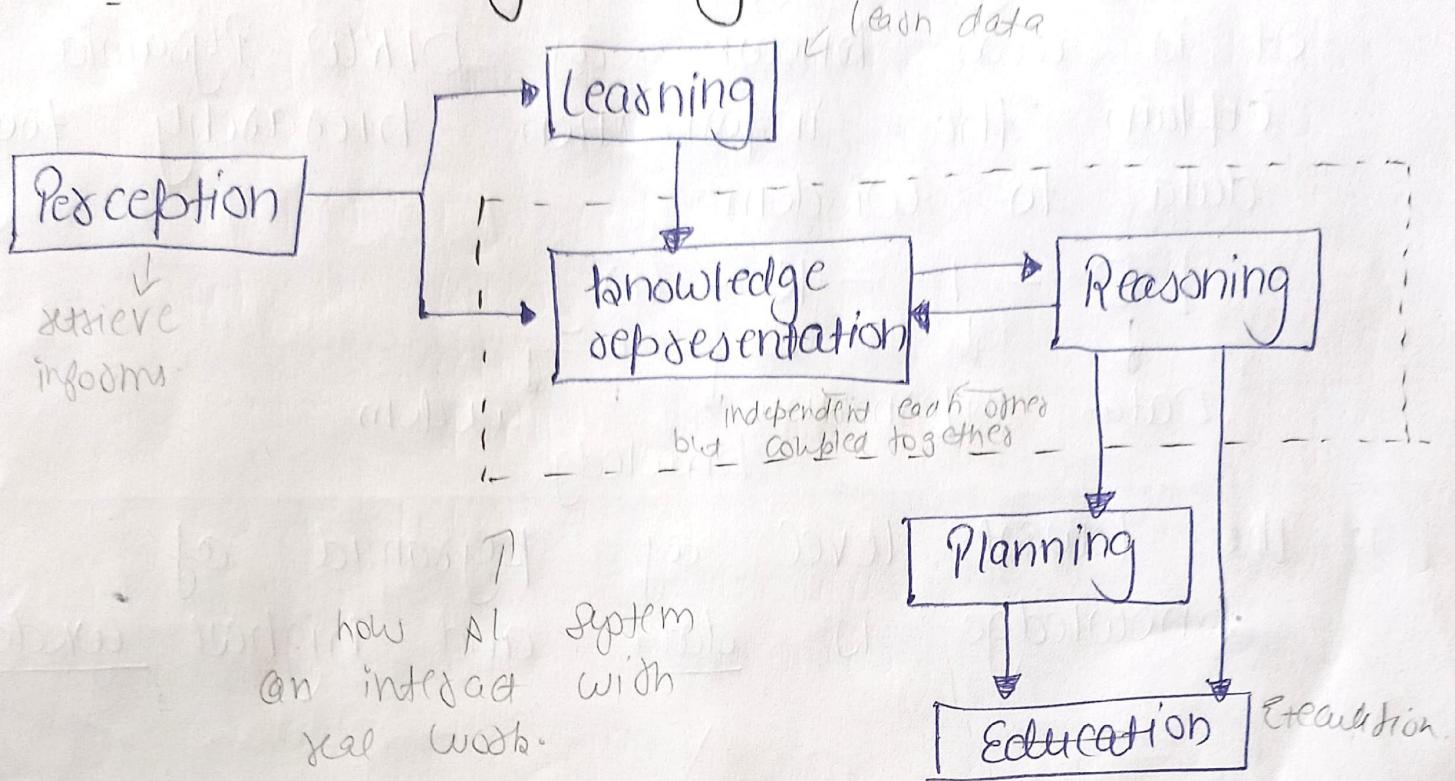
- 1) Declarative knowledge: is to know about something.
 - include concepts, facts and objects.
 - also called descriptive knowledge.

e.g.: → The Capital of Paris.
- 2) Procedural knowledge: which is responsible for knowing how to do something.
 - also known imperative knowledge.
 - include rules, strategies
- 3) Meta knowledge:
 - knowledge about the other type of knowledge
 - improve the performance of AI

[helps in efficient utilization]
- 4) Heuristic knowledge:
 - representing knowledge of some experts in a field.
 - based on past experience.

[acquired by experience]
- 5) Structural knowledge:
 - basic knowledge to solve problem.
 - describe relation that exist b/w concepts & object
 - factual knowledge

AI knowledge cycle



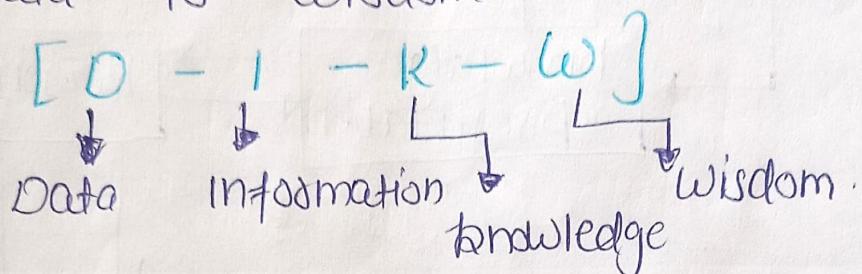
Difference b/w knowledge & Information

- **knowledge:** It is the collection of Skills and information
 - Can be gained from education, experience and practice
 - Awareness of something
- **Information:** It is ability to apply knowledge
 - Inborn and cannot be gained.
 - is a person ability to gain knowledge and skills and ability to use them.

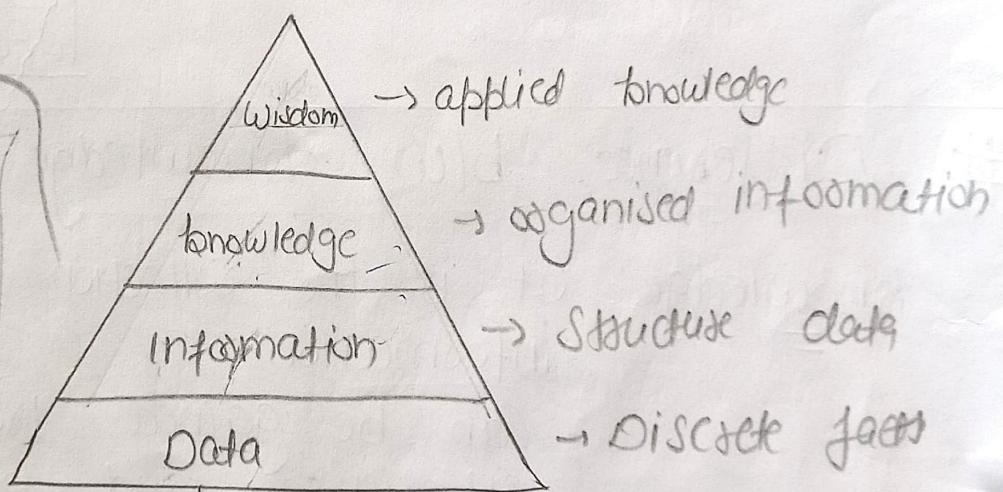
knowledge Pyramid

It represents the hierarchy of info in AI system.

- It is also known as explain the information data to wisdom.



- The lowest level of pyramid of knowledge is data and highest wisdom.



- **Wisdom:** It is the ability to make well-informed decisions and take effective action based on understanding of underlying knowledge.

- **knowledge:** It is derived of analyzing and interpreting information.
 - It provides an understanding of "How" and "Why" certain phenomena occurs.

- Information: Is organized, structured and contains data.
 - It is useful for answering basic questions like "Who", "What"
- Data: Refers to raw, unprocessed facts and figures or in unauthorized form. Data can be structured or unstructured and may include text, image

Characteristics of AI Problems

- The problems that AI tackle have a combinatorial explosion of solutions.
- AI program manipulate symbolic information to a larger extent.
- In contrast to conventional program which deals with numeric processing.
- AI program deals with real life problems. These assist human in taking right decision.
- One of the vital characteristics of AI program is its ability to learn.
- For combinatorial explosion of solⁿ, AI program use heuristic to prune the search tree.

[Heuristic are also used for problem where no general algo. are known.]

↳
[facial
recognition
NLP]
Deep learning

[human interaction]
Data quality

- Completeness → ^{completeness} task
- Non-linearity
- Ambiguity
- Adaptability

Problem Representation in AI

- Before a solⁿ can be found, the basic condⁿ is that the problem must be defined very accurately.
- Common method to represent problem
 - 1) State Space representation
 - 2) Problem deduction.

1) State Space Representation:

\downarrow Condⁿ and situation in a particular time.

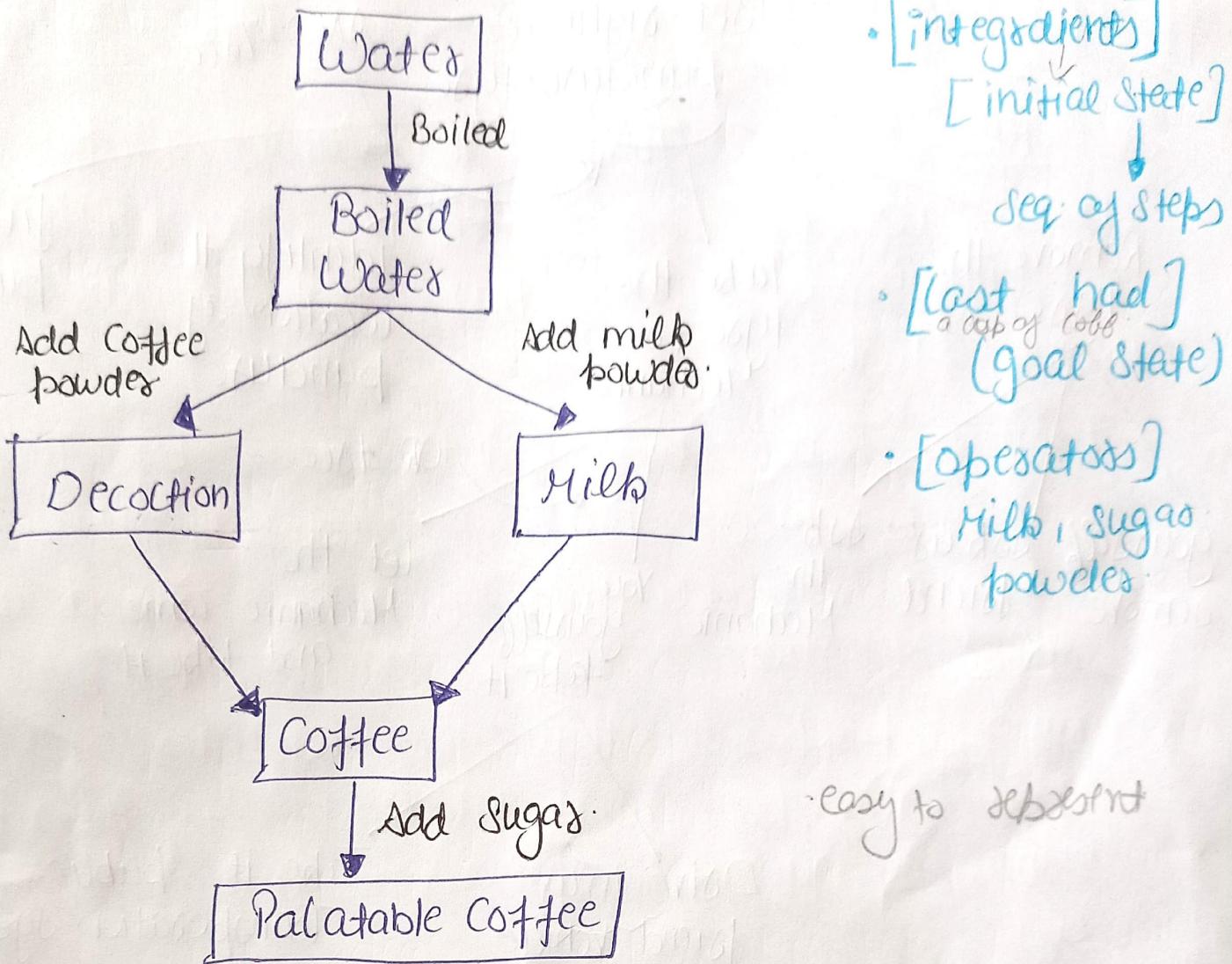
\rightarrow Movement Set of all possible states for a given problem.

- Suppose you are asked to make a cup of coffee. What will you do?
- Firstly verify the necessary ingredient like coffee powder, Milk, Sugar etc.

Steps

$\square \rightarrow$ Node $A \rightarrow \downarrow \leftarrow \uparrow, S \rightarrow$ Starting Node

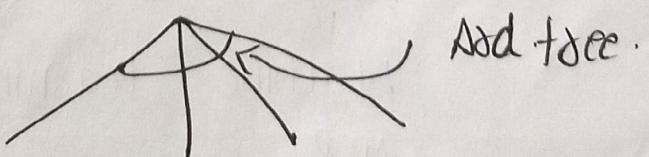
- Boil necessary water in kettle.
- Take some of boiled water in cup
- add necessary amount of instant coffee powder to make decoction.
- Add Milk powder to remaining boiling water to make milk.
- Mix decoction and Milk.
- Add sufficient quantity of sugar to taste
- Coffee is ready



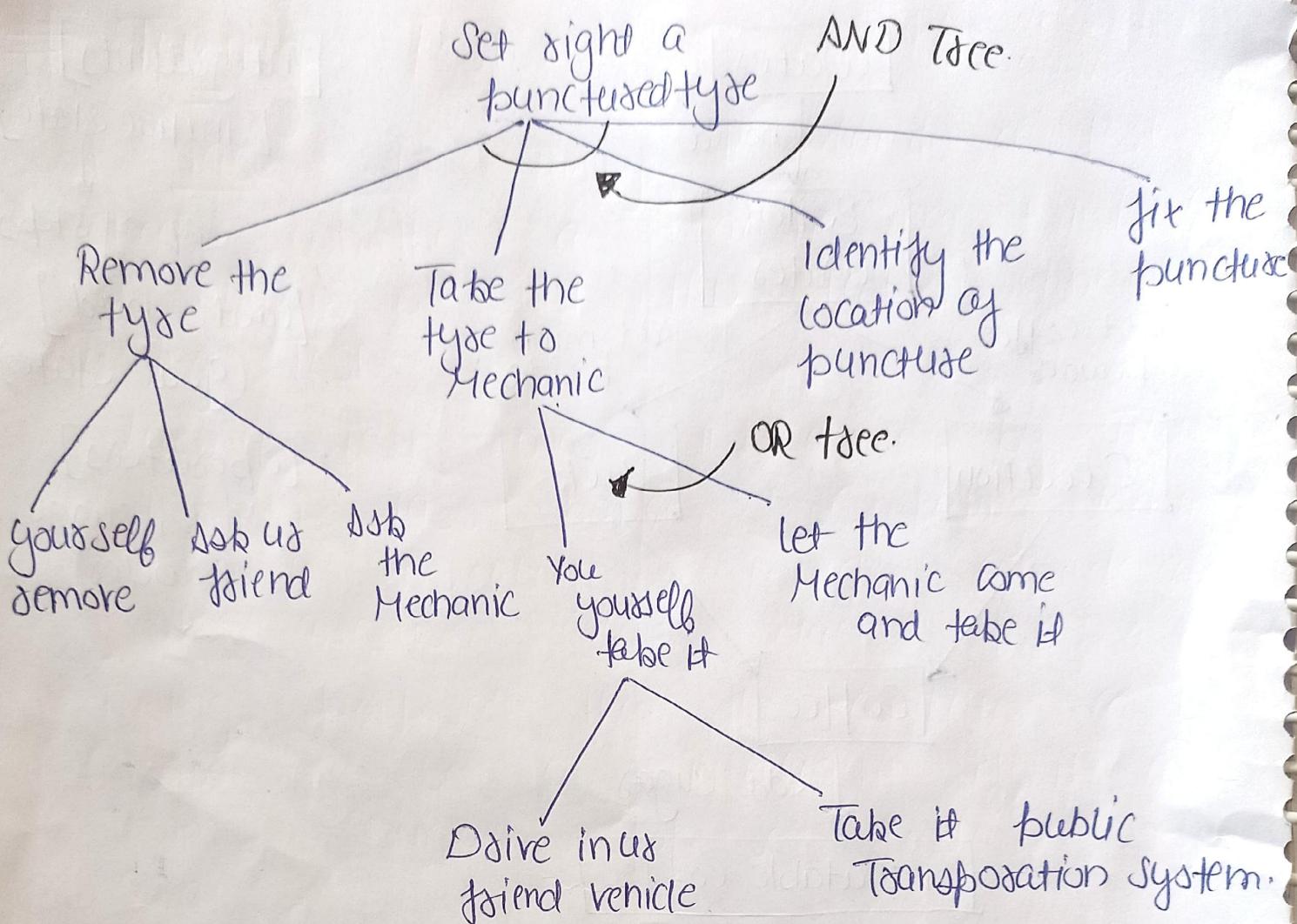
Q) Problem Reduction :) a large or complex problem is divided into small groups.

e.g. Set digit a punched tape.

- In this pictorial representation of AI problem by an AND/OR tree.
- An arc (\cup) connecting different branches is called Add tree.



OR Tree.



AND - OR Relationship

- Complete problem and Sub - problem exist in these two relationship.

→ AND - Relationship: find a problem solⁿ.

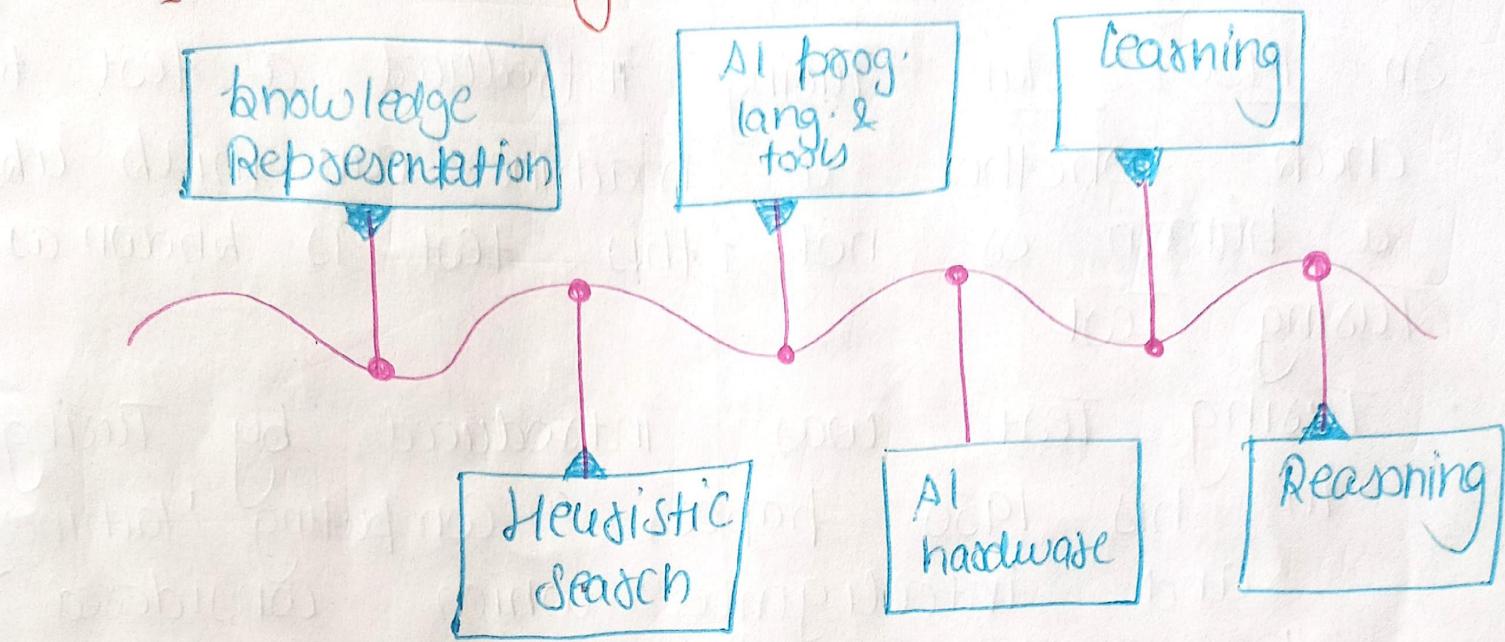
→ OR - relationship: a group of participants select one participant and find a solution.

forms and Technologies of AI

- Weak AI
- Strong AI

- Machine learning
- NLP
- Robotics

Components of AI



• knowledge representation :> It involves capturing and organizing info. in a way that is suitable for processing
→ logical representation

• Heuristic search :> which are rule of thumb
= rule or technique that guide the search process.
→ A* Algo.
→ to find sol'n b/w two places.

• AI hardware components: physical parts of computers that help it run AI programs
= Problem-solving approach designed to analyze problem and give best. → GPUs
→ TPUs

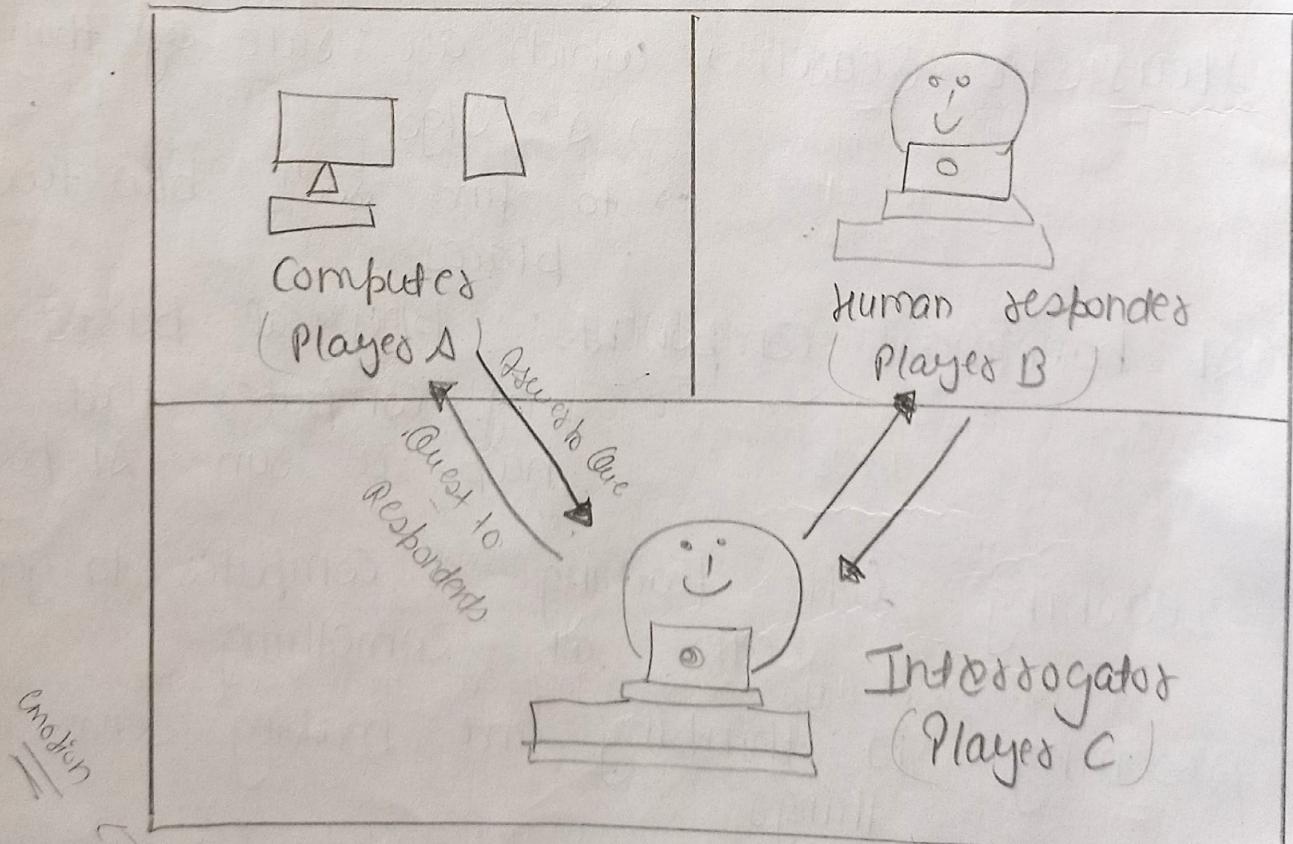
• Learning: like teaching a computer to get better at something.
= Can learn data and improve their performance over time.

• Reasoning: is thinking and making sense of things.
= do make logical and draw conclusion based on available information

Turing Test

British Mathematician and Computer Scientist

- In 1950, Alan Turing introduced a test to check whether a machine can think like a human or not, this test is known as Turing Test.
- Turing Test was introduced by Turing in his 1950 paper, "Computing Machinery and Intelligence," which considered the question "Can Machine think?"
- Turing proposed that the computer can be said to be an intelligent if it can mimic human response under specific conditions.



- Turing proposed an "imitation game", which was later modified by "Turing Test"
- This game involves three person in which
 - Computer
 - Person
 - Interrogator
- The interrogator can communicate with the other two
- The interrogator tries to determine which the person is and which the machine is.
- The Machine Tries to fool the interrogator into believing that it is the person.
- If the Machine succeeds, then we conclude that the machine can think.

If an interrogator would not be able to identify which is machine and which is human, then the computer pass the test.

- Machine is said to be intelligent and "can think like a human"

⇒ Chatbot or Chatbots to attempt the Turing Test

- ELIZA

Features → Natural language processing

→ Knowledge representation

→ Automated reasoning

→ Setting a Benchmark

#

Human

- Use brain power
- Basic unit is neuron.
- Has emotions
- Has the capacity to learn.
- Has self-awareness.
- Accuracy → can make mistakes
- Decision → can make their own decision

Human
Storage: Human may forget what they have learned and stored in their mind.

Computer

- depend on data
- Basic unit is RAM
- Dumb and no emotions.
- Must be programmed.
- Still working towards self-awareness.
- never make mistake.
- require human instruction to work.
- Store a lot of information and remember all of it all the time.

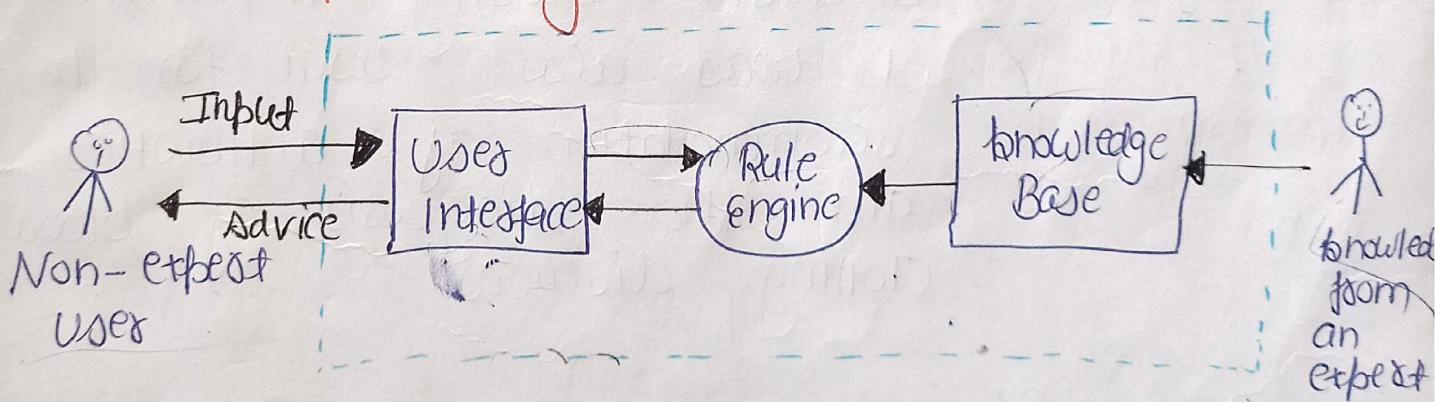
Expert Systems

ability to make decision teams of computer science attached with expert.

- Expert system is a computer program or computer software that is designed to solve complex problems and to provide decision-making ability like a human expert.
- It is a part of AI and first developed in 1970.

Ex: suggestion of spelling errors while typing in Google search bar.

Block Diagram represents the Working of an Expert System



- expert system is not used to replace the human experts, it is used to assist the human in making a complex decision.

Examples

1) DENDRAL : [

↓
1965

Domain :- Chemistry

function :- Data analysis.

- It was an artificial intelligence project that was made as a system for chemical analysis expert system.
- It was used in organic chemistry to detect unknown organic molecules with the help of their mass spectra and knowledge base of chemistry.

2) MXCIN : [

↓
Developed
by
Stanford
University.
[1970]

Domain :- Medicine

function :- Diagnosis

- It was one of earliest backward chaining expert system that was designed to find the bacteria causing infection.

English equivalent:
IF → site of infection
AND → site of culture
AND
Then

- It was also used for the recommendation of antibiotics and the diagnosis of blood clotting diseases.

3) XCON/R1 : [

Domain :- Computer System Configuration

function :- Design

- It is a rule based computer program that configures VAX-11 computer systems.

Characteristics of ES

→ High performance: for solving any type of complete problem of a specific domain with accuracy.

→ Understandable: It responds in a way that can be easily understandable by user [i.e. our Natural language]

Good → Reliable: much reliable for generating an efficient and accurate output (without any error)
 Consistency → Not work with moment work continuity

→ Highly responsive: ES provide the result for any complete query within a short time.

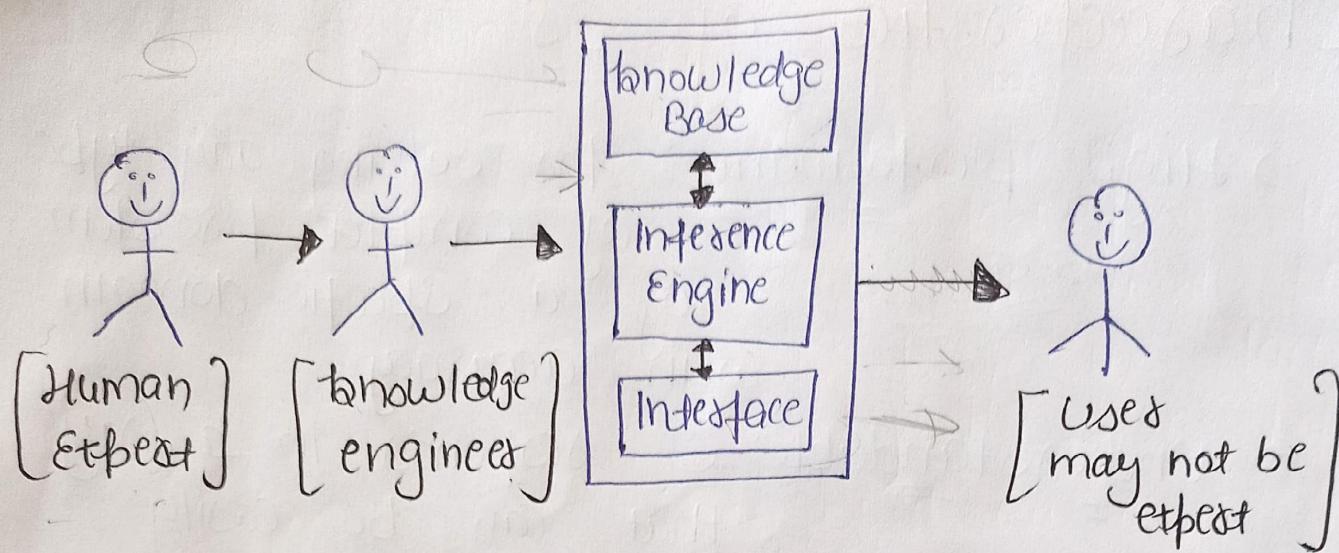
• Learning Capability
• Domain Specificity
• High efficiency

Components of Expert System

An expert system mainly consist of three components.

- User interface
- Inference Engine
- Knowledge Base
- Domain-specific: deal with all kind of knowledge about a particular domain.
- Common-sense: → increases performance of system.

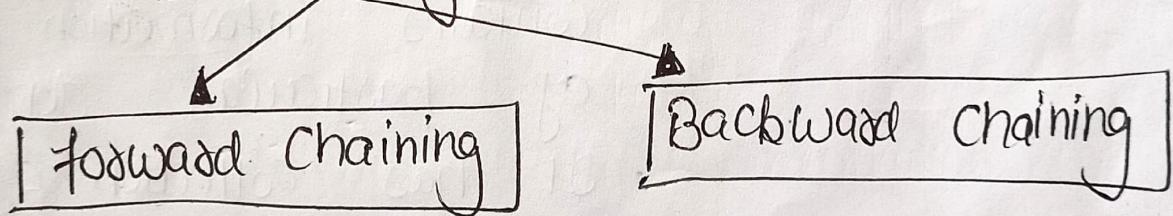
about events, objects,
task-performance



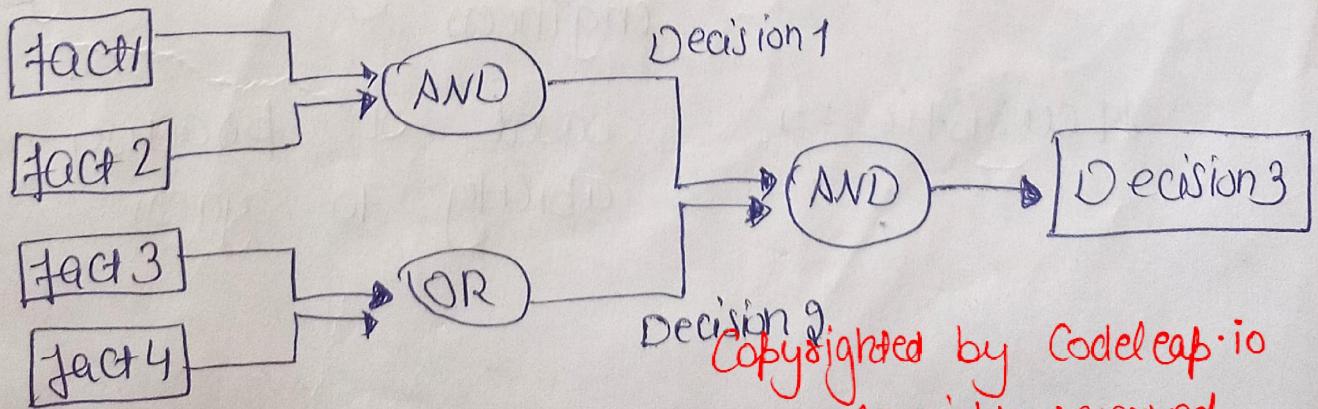
- Human expert: Who have the knowledge
 = Domain specific knowledge of specific domain expert
 • Common sense.
- knowledge engineer: a person who have the knowledge of computer.
 =
 → factual
 → Heuristic Based
 • Who gather the knowledge from domain experts.
- User - interface: It is way of communication where we interact with computer of expert system.
 =
 • Takes queries as input in a readable format and passes it to inference engine.
 after getting the response from the inference eng. and display the output to user.
 • In other words, it is an interface that helps a non-expert user to communicate with the expert system to find a solution.

- Inference Engine:
 - Probabilistic
 - Deterministic [based on [assumed to be true.] [based on facts & rule] [based on rule]
 - IF - Then]
- (Rule of engine) also known as the brain of expert system and main processing unit of system.
- It applies IE to the knowledge base to derive a conclusion, new information deduce.
- With the help of IE, the system extracts the knowledge from the knowledge base.

\Rightarrow Approaches of IE

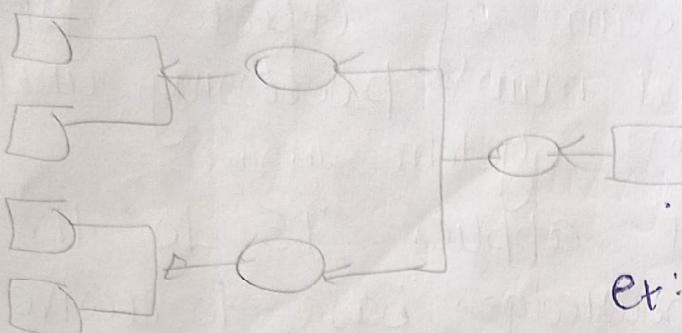


- forward Chaining :> also known as data-driven search.
 - [IF condⁿ Match]
 - [What will happen Next]
- get facts from the known [facts & rules]



• Backward Chaining:

= [Then Condⁿ]



also known as Consequent driven search.

- that start from the goal and work backward to prove the facts
- "Why this was happened"

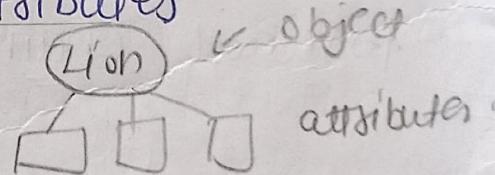
ex: → blood cancer.

• Knowledge Base:

=
↓
big storage of knowledge

The knowledge base is a type of storage that store knowledge acquired from different expert.

- Similar to Database that contains information & rule of particular domain.
- It has collection of object and attributes.



⇒ Components of KB

- factual : based on facts and accepted by knowledge engineer.

- Heuristic : based on practise, the ability to guess.

Advantages

- Accuracy
- Multiple expert
- Maintenance → 24x7
- Development of increase accessibility
- High speed to respond query.

Scalability

High reliability

accessibility

query.

More usg
flexible

Limitations

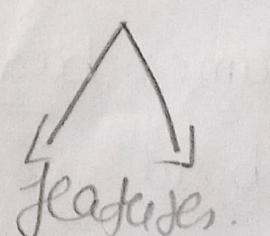
- Not have common-sense knowledge
- development cost high.
- No flexibility for user.
- knowledge acquisition for designing is much difficult.
- Cannot learn from itself

high dev cost
No creative response
no flexibility

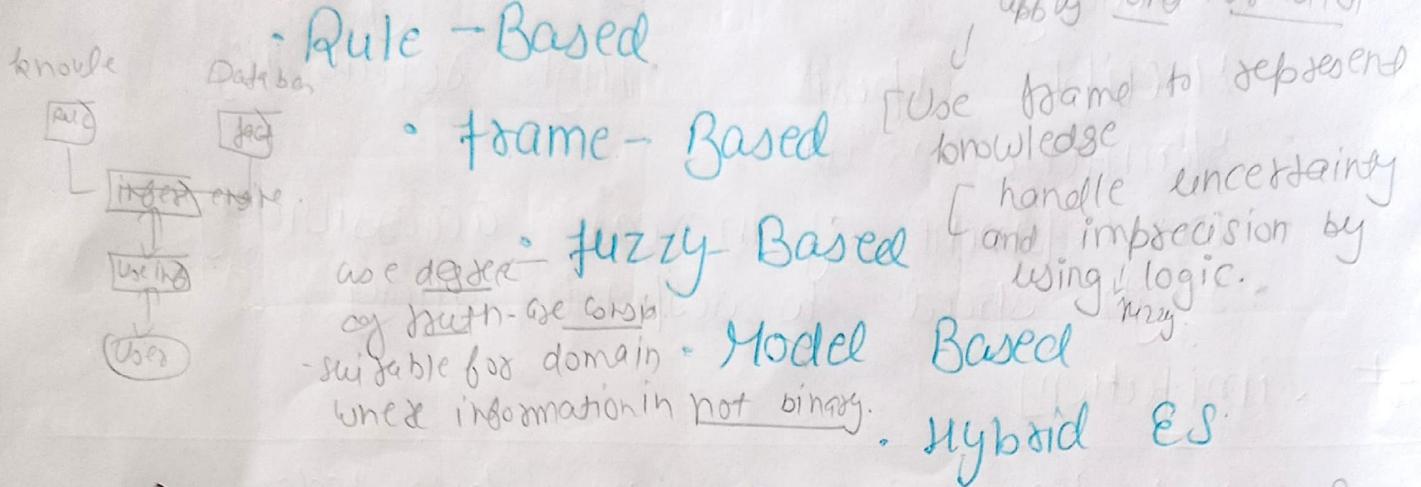
lead to
efficiency

Applications

- In designing and manufacturing domain. [Automobile]
- Medical → Diagnosis [analysis, symptom, patient history]
- Analysis
- Control [process monitoring]
- Instruction
- Monitoring [out camera need]
- Planning → achieve task.
→ detect any fraud.
- finance. → Trading
Stock Market
- Education → Inter's
- Customer support [automatic crop]
- Agriculture → feeding info. [mobile] [car switch]



Categories of Expert System



- Rule - Based: [condⁿ apply] [set of rules]
 - They use a set of explicitly defined rule to represent the knowledge of Human experts.

Suitable for heuristic knowledge.

- knowledge base
- Database
- User interface
- inference engine

Ex: if symptoms include fever then

the diagnosis might be flu.

- Model - Based: It use different approach to represent knowledge.
 - use a formalized model of problem domain.
 - It capture the relationships, constraints with problem space.
 - Models can be complex.
 - More flexible.
 - less Transparency

cause & effect
relationship

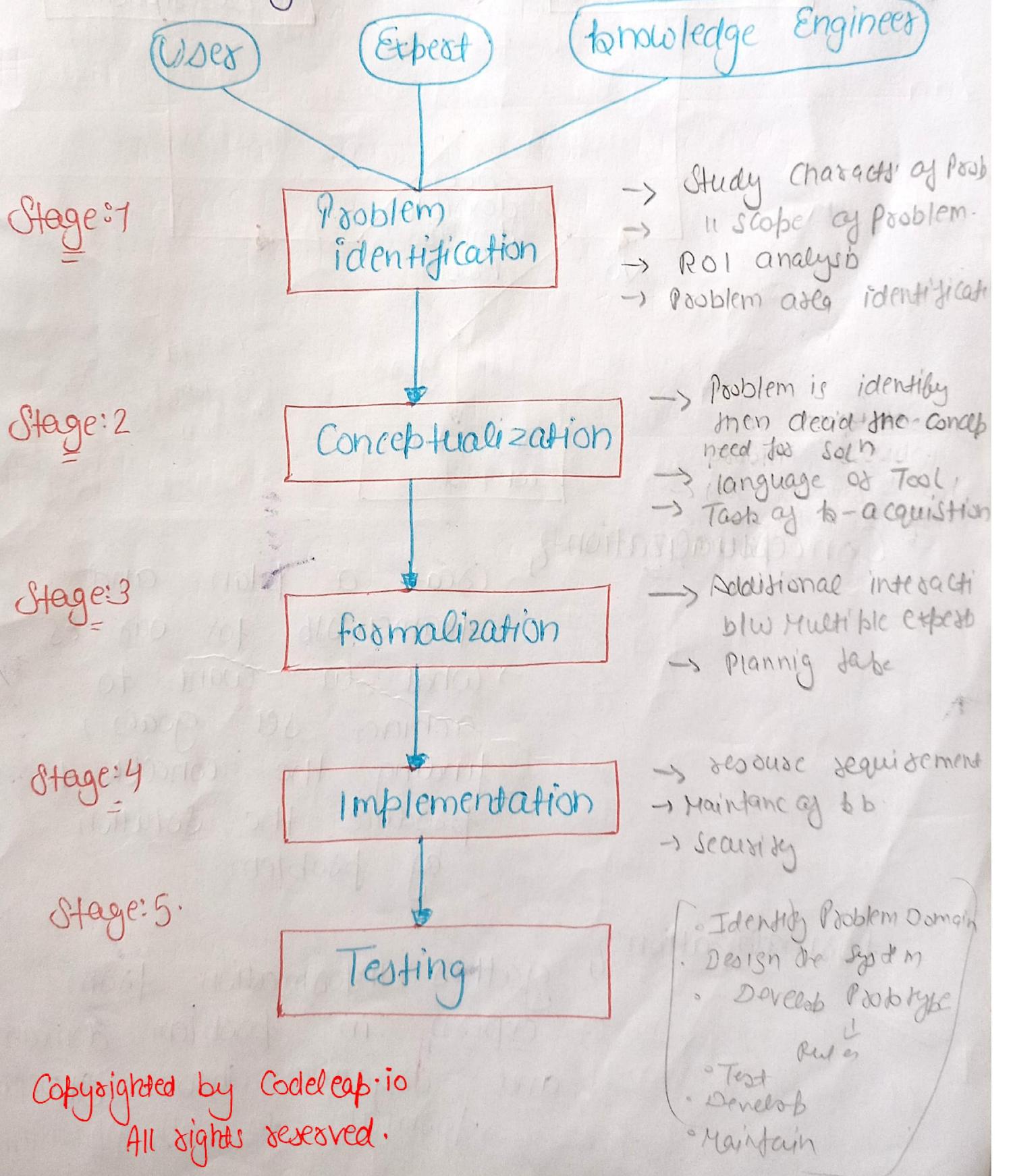
- frame - based: [condⁿ Yes/No]

- Hybrid ES: all above system add.

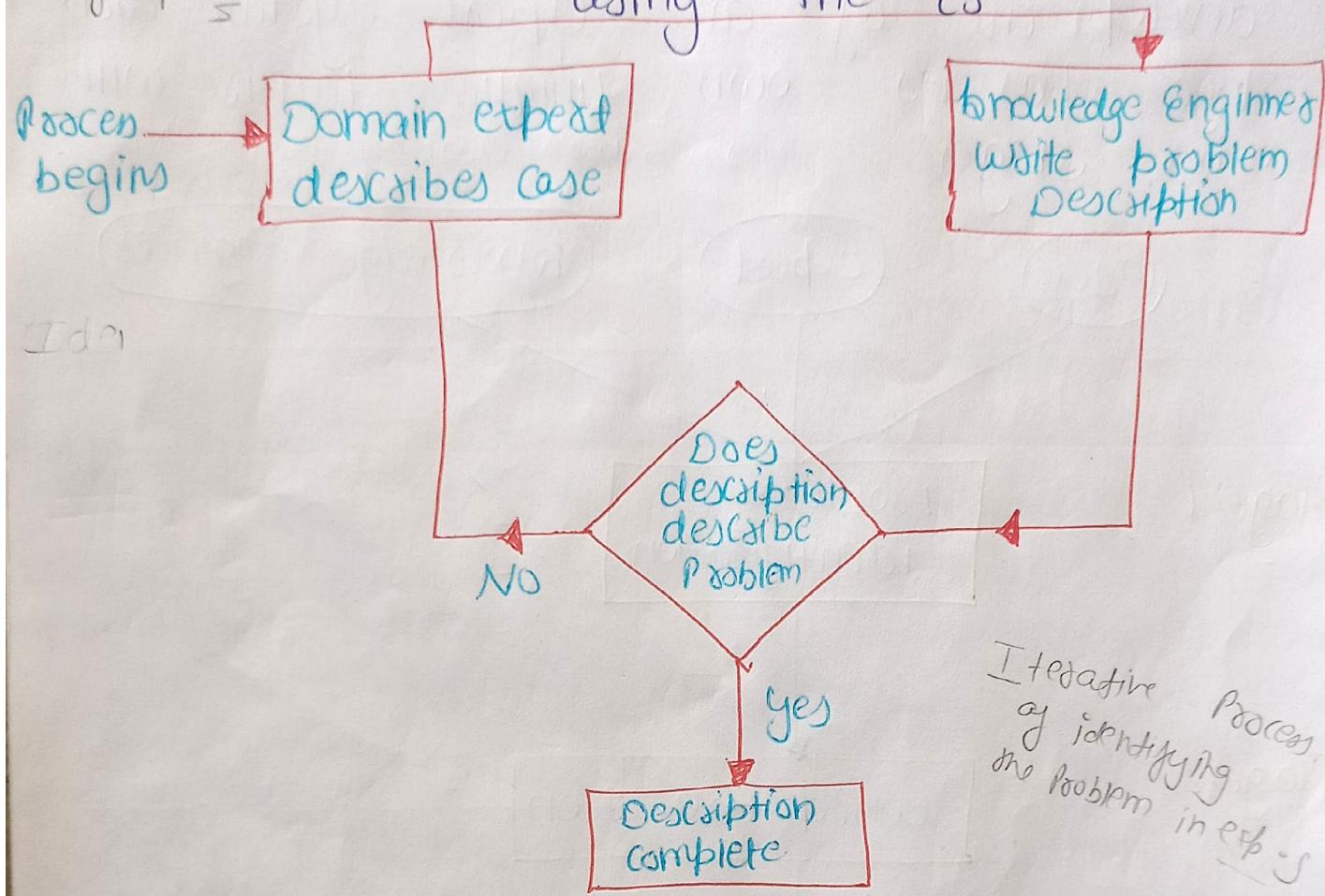
Life Cycle of Expert System

- These are five major stages in the development of an expert system. each stage has its own unique feature with other stages.

usually work close to each other through prototyping



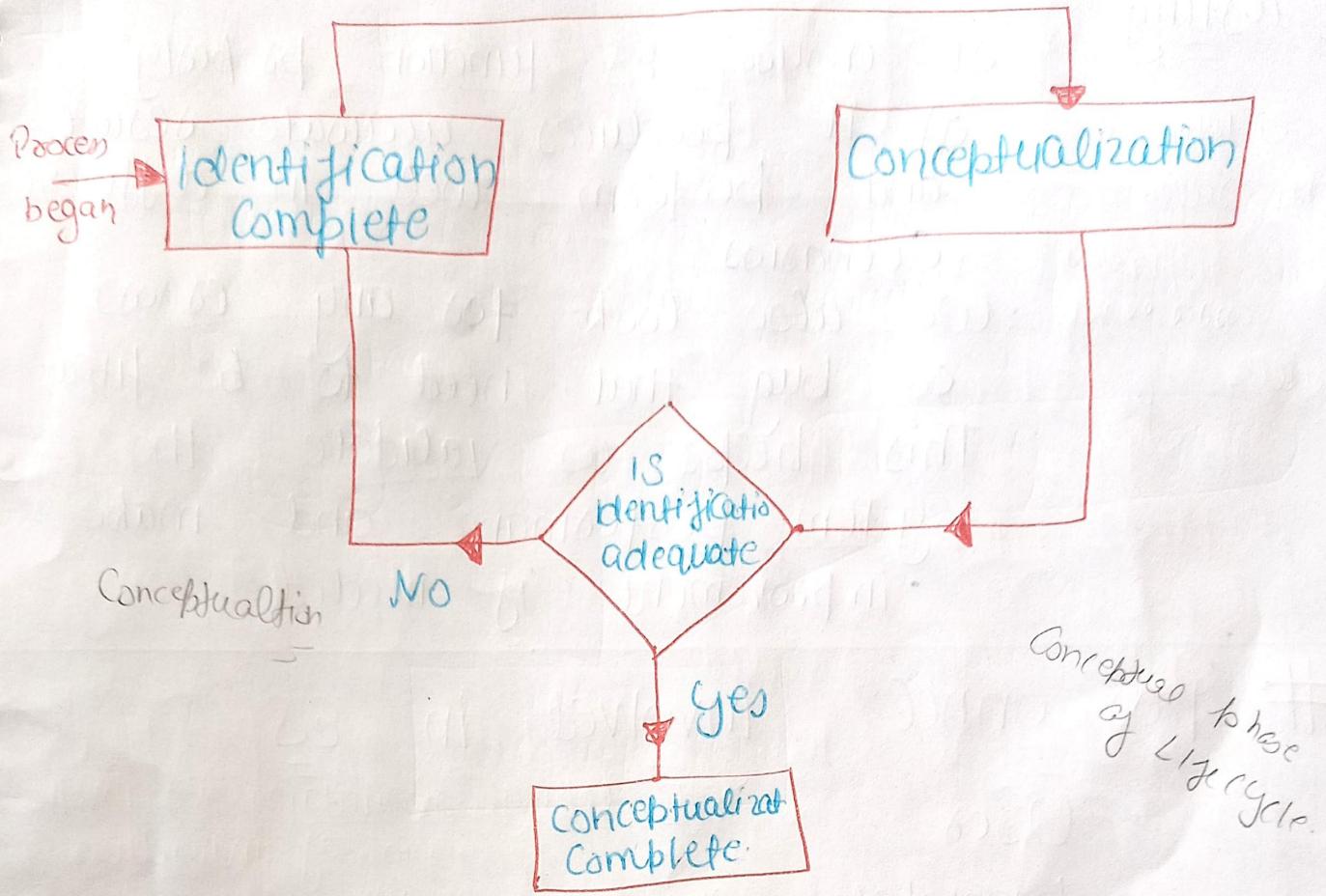
- Identification:
Determining the character of problem
figure out the specific problem we want to solve using the ES.



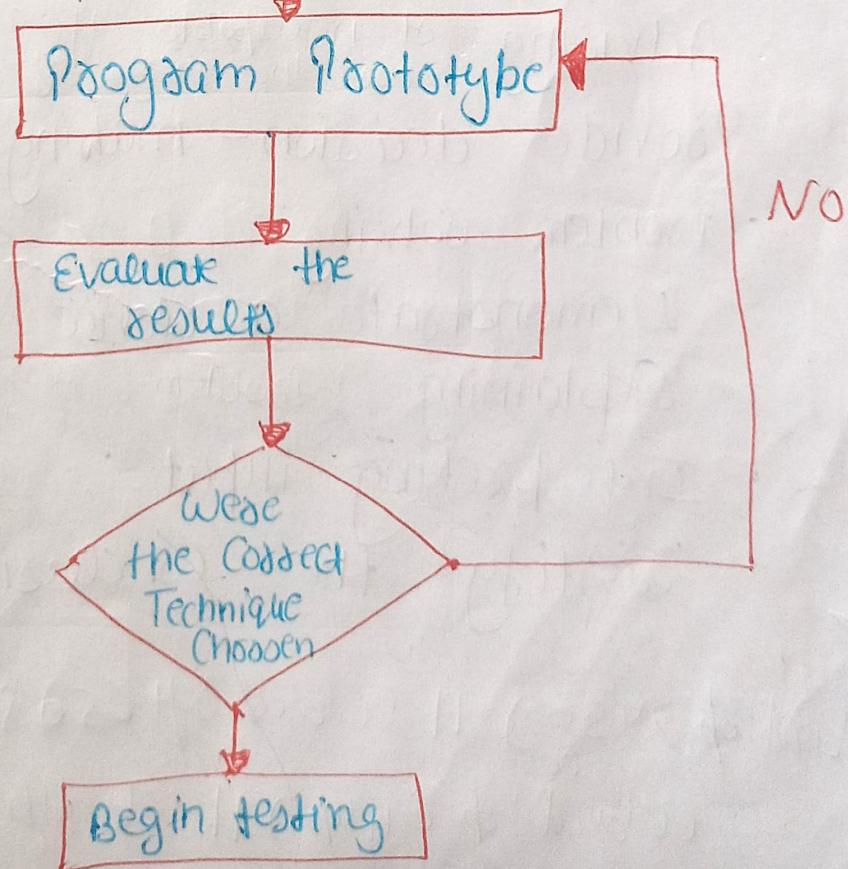
Iterative process of identifying problem in steps

- Conceptualization:
Create a plan and framework for our ES.
 → what we want to achieve, set goals;
 • finding the concept to produce the solution of problem.

- Formalization:
Designing structures gathered information from experts in problem domain to organize the knowledge and organize into format to solve problem.



- Implementation: The phase where we have to write down the code for the given problem.
Imp. stage begin.



- Testing : to ensure ES function properly
- Validating the rules.
- System implement correct & not nulls
- If it produces accurate result and perform well in different scenarios.
- We also look for any errors or bug that need to be fixed.
- This helps us validate the system performance and make improvement if needed.

Personnel involved in ES

- User → developing & maintaining ES involve a team of individual with skill & expertise
- Knowledge engineer ← problem find in my domain
- Domain expert → a person who have specific knowledge & skill in my field
- System Maintenance personnel.

Capabilities

- Advising [it is capable of advising the human being for the query of any domain]
- Provide decision-making [in any domain]
- Problem solving [by applying logical rules]
- Demonstrate a device → any new product [how to use]
- Explaining a Problem [also capable for provide a detailed description of input problem]
- Interpreting input → [understanding & processing information by user]
- Justify the conclusion.

ES Tools

→ Knowledge Acquisition Tools
" " Tools
Video Interface Tools
All

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→ AGE

→ EMYCIN ← Structure elements

→ Coops

• Powerful editors for user interface.

• The right environment for expert to communicate

• Helps in rapid prototyping.

knowledge Acquisition

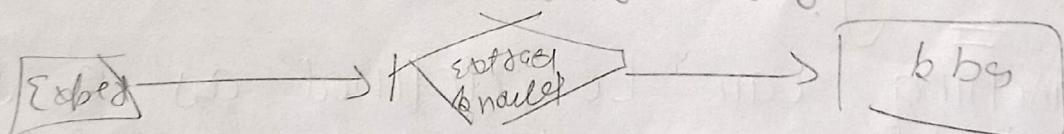
It is the process of extracting, organizing and structure the domain knowledge

• The process of acquiring knowledge from human experts and encoding it into the knowledge bases.

knowledge rep → if - else rule

↳ Participate in Development Expert

knowledge Eng. need
- end - used



AI and Search Process

↳ Step by step procedure to solve a search problem

- Every AI Program has to do process for searching for the solution Steps are not explicit in nature.
- To do a search process, the following State are needed:

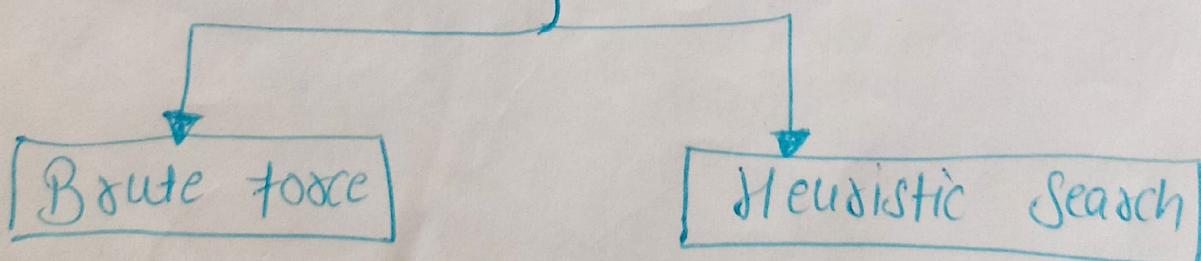
* Initial State: description of problem.
eg:- the initial positions of all pieces in chess board.

* Set of legal operators: that change the state, like rules of games.

* final or goal state: that a problem solver has to reach in order to succeed.

Searching

Searching can be defined as a sequence of steps that transforms the initial state to the goal state.



- Technique of Searching.

- Brute force Search, also known as "uninformed search", "Blind search".
 - These are commonly used search procedure which explore all the alternative during the search process.
 - They do not have any domain-specific knowledge.
 - All they need are the initial state, the final state and a set of legal operators.
 - Some important techniques
 - 1) Depth - first search
 - 2) Breadth - first search.
 - In case of algorithm: that explore a search space without using any additional information about the problem
→ These algorithms systematically generate and Test all possible solution until a satisfactory one is found [goal state].
 - easy to implement, but not be efficient in all cases, when the search space is large
 - expensive in large problem Space.
 - give guarantee.

- Q) Heuristic Search: also known as "informed search"
- The brute search have not any domain-specific knowledge. The process of searching can be drastically reduced by the use of heuristics To find solⁿ
 - They have domain-specific knowledge
 - The heuristic are needed for solving problems are generally represented as a heuristic function which map the problem states into numbers.
 - Some important techniques [solve quickly]
 - 1) Hill Climbing
 - 2) Best-first Search
 - 3) A^{*} & AO^{*} Algorithm
 - 4) Constraint Satisfaction.
 - In Case of algorithm: uses additional information to guide the search process. This information to make intelligent decisions during search. is called heuristic, Heuristic are rule of estimates that provides a measure of how close a state is to goal state.
 - More efficient than uninformed search.
depend upon quality of heuristic used.
 - Not guarantee.

Properties of Searching

- Completeness
- Optimality
- Time Complexity
- Space Complexity

Difference b/w formal & informal

Formal Search

- Also known as Brute force search.
- Structured approach:
It follow a systematic and structured process
- follow set of guidelines.
- Explicit Criteria: Specific criteria and parameter are defined in advance. These criteria help narrow down the search.
- Database and Catalog Usage: relies on database, catalog.
- Rigorous analysis
- Search without information

Informal Search

- also known as heuristic search.
- Unstructured approach:
less structured and follow the step or guideline.
- Flexible Criteria:
It lack explicit criteria, User may conduct searches with vague.
- General Search Engines:
like google designed for broad information.
- less formal analysis.
- with information

[In heuristic, goal state value always contain zero $[h(n)]$].

• Depth - first Search, This is very simple type of Brute-force search technique.

- The search begins by expanding the initial node. i.e. by using an operator, generate all successors of initial node and test them.

[Stack]

→ Algorithm

Step1: Put the initial node on a list START

Step2: If (START is empty) or (START = Goal)
terminate with search

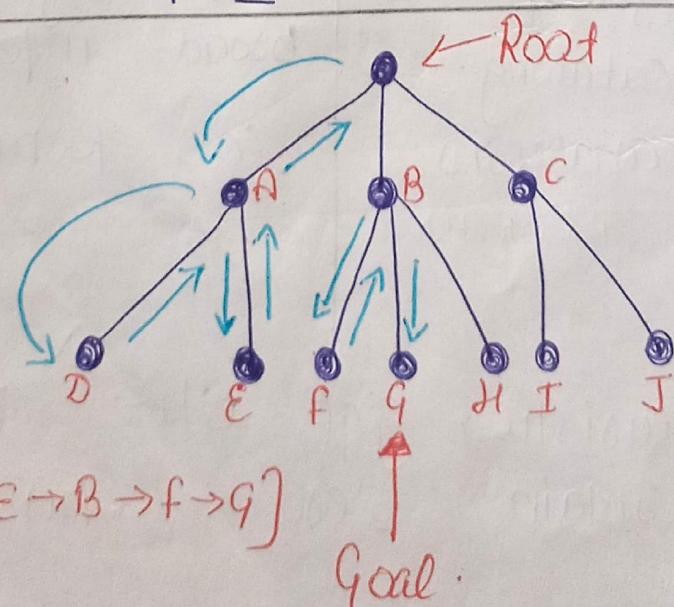
Step3: Remove the first node from START,
call them node a.

Step4: If (a = Goal) terminate with success

Step5: If a has successor, generate all of
them & add them at the beginning
of START

Step6: Go to Step 2;

→ Example:



[S → A → D → E → B → G]

Goal.

- Two important factors to be considered in any searching procedure.

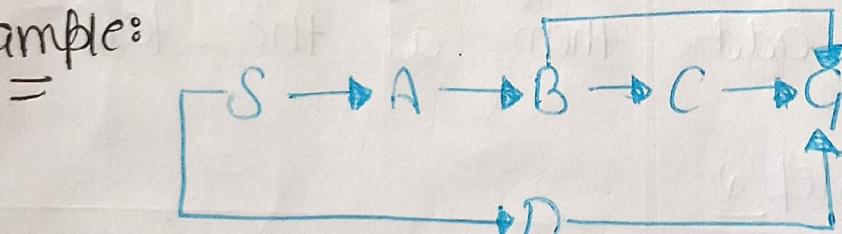
Time Complexity

- It measure of time for an algo. to complete its task.
- $O(b^d)$

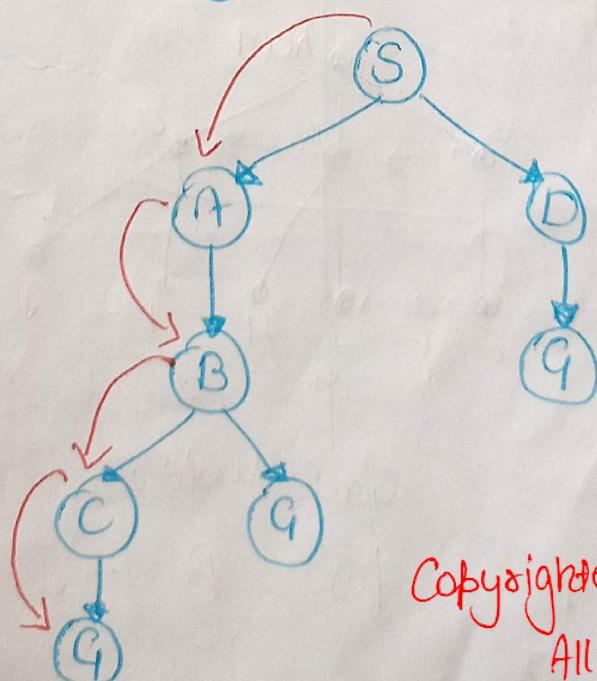
Drawback \rightarrow Not find shortest path.

- Determination of depth until which the search has to process called cut-off depth.
- \rightarrow If cut-off depth is smaller, soln may not be found.
- \rightarrow If cut-off depth is large, time-complexity will be more.

Example:



\rightarrow Traversal =



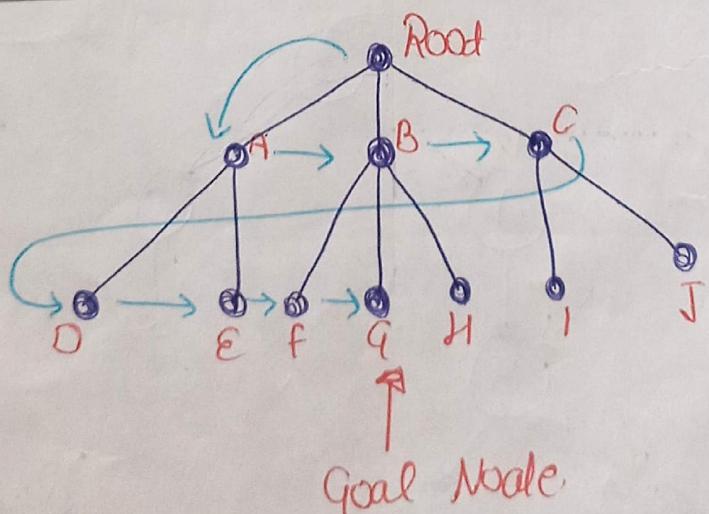
Deepest
node & jst

$[S \rightarrow A \rightarrow B \rightarrow C \rightarrow G]$
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- Breadth First Search: Searching progresses is level by level.
 - follow a direction.
 - start from first root and generate all possible children of node.
 - implemented using a queue.

=> Algorithm:

- Step 1: Put the initial node on list START
- Step 2: If (START is empty) or (START = Goal) terminate with success.
- Step 3: Remove the first node from START.
call them node a.
- Step 4: If (a = Goal) terminate search with success
- Step 5: If a has successors, generate all the them & add them at the tail of START.
- Step 6: Go to Step 2.



- Search tree for B-F-S

* Has to DFS, the two major factors

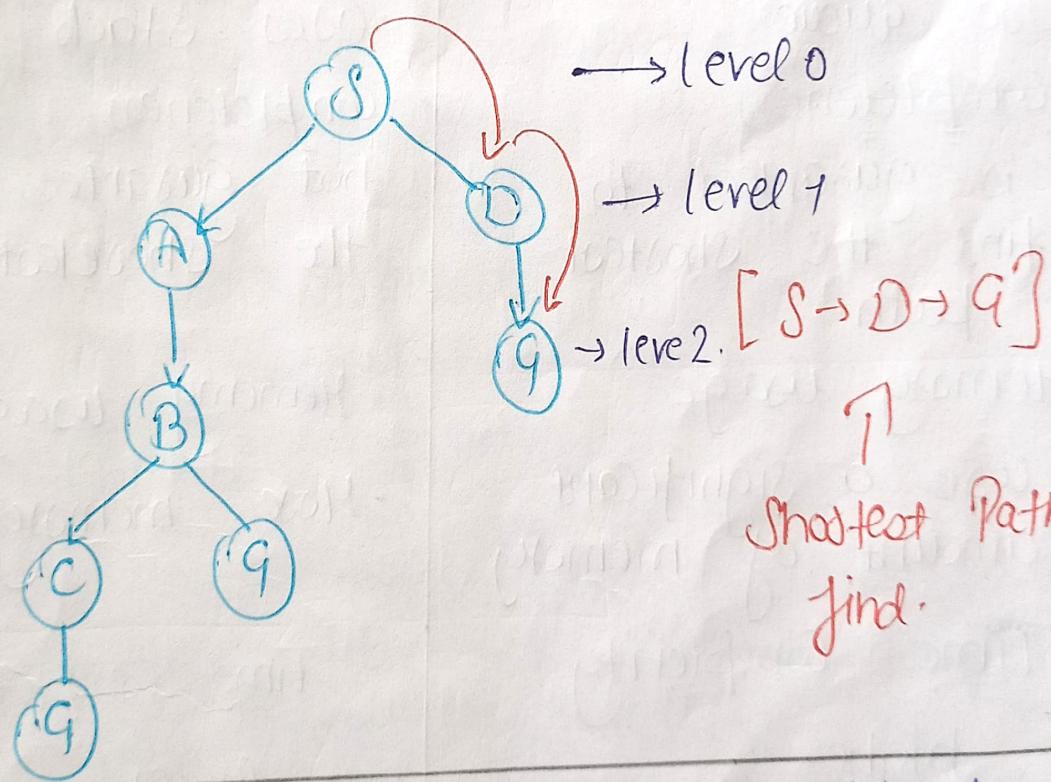
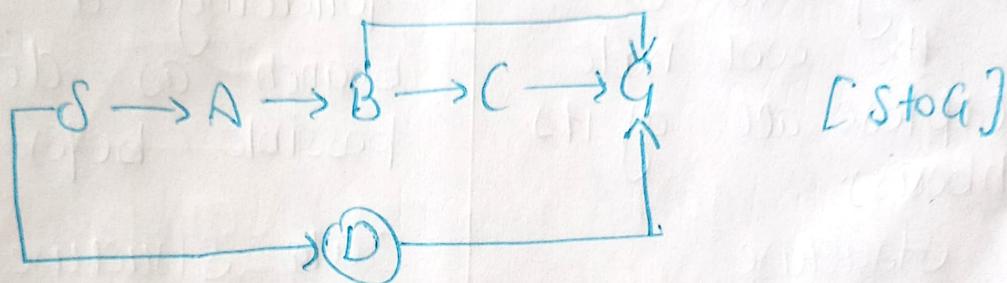
→ Time Complexity: $O(b^d)$

→ Space Complexity: $O(b^d)$

→ Problem

• Amount of time needed to generate all complexity
node because of time

Ex:



• Completeness: A search algo is said to be complete if it is guaranteed to return a solution if atleast any solⁿ for any random i/p.

Difference

BFS

- both are fundamental graph traversal algo
- Order of Exploration:
 - It explores nodes level by level. It starts the root node and explore all of its neighbours.
- Data Structure: Use queue.
- Completeness: is guaranteed to find the shortest path.
- Memory usage: use a significant amount of memory
- Time Completeness: higher

DFS

- same fundamental graph traversal algo
- Order of Exploration:
 - It explodes node by following a single branch as deeply as possible before backtracking.
- Data Structure: uses stack.
- Completeness: not guarantee finding the shortest path.
- Memory usage: more memory-efficient.
- Time Completeness: lower.

• Optimality: if a solⁿ for an algo is guarantee to be best solⁿ. [lowest path] among all other solⁿ. Then such algo /solⁿ is said to be optⁿ.

- Hill Climbing
 - It is a heuristic search used for Mathematical optimization problems.
 - Hill Climbing algorithm is a local search algorithm which continuously move in the direction of increasing value to find the best soln to the problem.
 - It terminate when it reaches a peak value where no neighbor has a higher value.

Ex: → Traveling Salesmen problem in which we need to minimize the distance traveled by salesman.

Features

- 1) Greedy approach
- 2) No Backtracking
- 3) Generate & Test

[Types]

- Simple
- Steepest-Ascent
- Stochastic

State-Space Diagram

It is a graphical representation of set of states our search algo can search the function which maximize value [global]

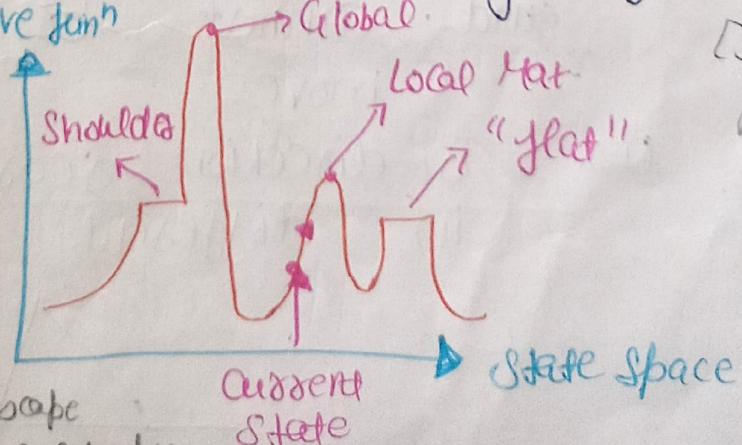
◦ x axis: denote space state.

◦ x axis: denote value of objective function
[objective fun]

◦ Global: highest value of objective function

◦ local: better than its neighbor states.

◦ Current: state in landscape diagram where agent present



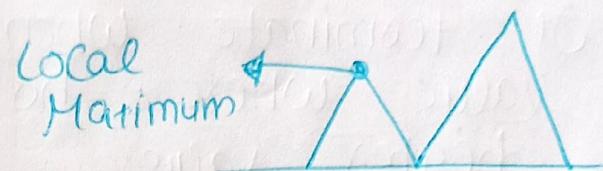
[Shoulder Plateau region which has uphill edge.]

Problem with hill Climbing

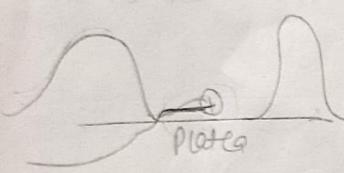
1) Local Maximum : It is peak state in landscape which is better than each of its neighbouring states.

Best off is high present local Max.

Solⁿ: Backtracking technique. Solⁿ of local Mat in State space landscape.

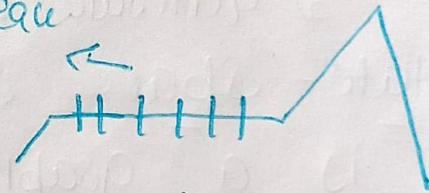


2) Plateau: flat area of search space in which all neighbor states of current state contain the same value, because also not find any best direction to move.

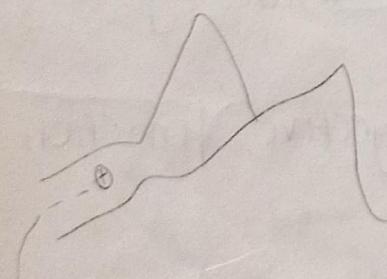


Solⁿ: take big steps or little steps while searching.

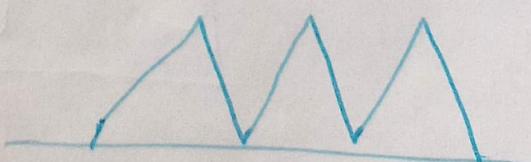
to solve the problem
Randomly select a step.

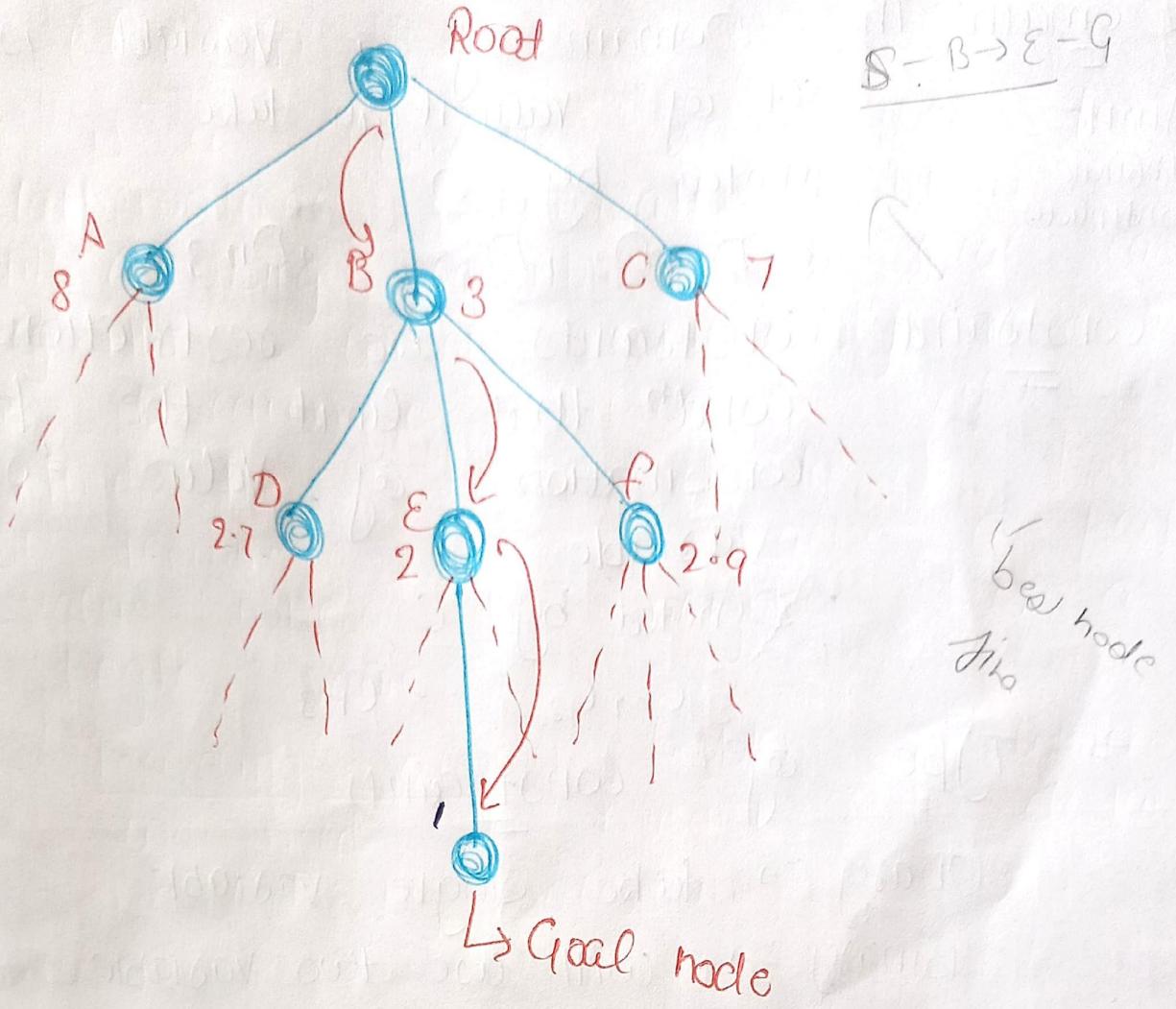


3) Ridges: Special form. It has an higher than area, but and cannot be reached in single move.



Solⁿ: use bi-direction search or by moving in different direction.





Constraint Satisfaction

It is a technique deal with identifying constraint which deal and find out the solution that satisfies a set of constraints.

- backtracking algo.
- forward-checking
- propagating constraint

→ Constraint Component

1) Variable. These are the entities whose value need to be determined.

- Denoted by V

- $\{V_1, V_2, V_3, \dots, V_n\}$

- Domain: The Domain of a variable is the set of values it can take.
 - Finite
 - Infinite
 - Continuous
- Constraints: Constraints are restrictions or cond'n that limit the possible combination of values for variable.
 - Denoted by \underline{C}
 - $\{ C_1, C_2, \dots, C_n \}$

Type of constraints

- Unary \Rightarrow take single variable.
- Binary \Rightarrow will use two variables.
- Global \Rightarrow will take more than variable and specify complete relations.

Representation [How to constraints are satisfied]

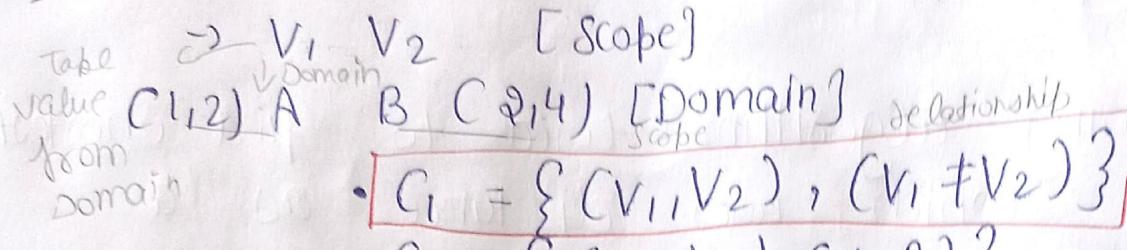
- V is set of variables $\{ V_1, V_2, \dots, V_n \}$
- D is set of Domains $\{ D_1, D_2, \dots, D_n \}$ one for each variable
- C is set of constraints that specify allowable combination of values.

$$C_i = (Scope, relationship)$$

\rightarrow Scope: set of variables that participate in constraint.

\rightarrow Relationship: define the value that variable can take.

eg: Constraint $\{C_1, C_2, C_3\}$

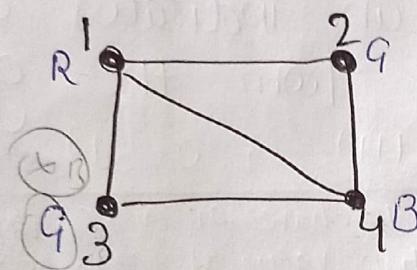


after applying some domain value.

$C_1 = (V_1, V_2, C_{1,2}) \quad C_{2,4} \rightarrow \text{Constraint is satisfied.}$

eg: SUDOKU, Graph Coloring.

eg:



$V = \{1, 2, 3, 4\}$

$D = \{\text{Red, Green, Blue}\}$

$C = \{1 \neq 2, 1 \neq 3, 1 \neq 4, 2 \neq 4, 3 \neq 4\}$

[use Backtracking]
Intelligent

	1	2	3	4
Initial Domain	RGB	RGB	RGB	RGB
$1 = R$	R	GB	GB	GB
$2 = G$	R	G	GB	B
$3 = B$	R	G	B	(B)
$4 = Y$			[a]	[B]

[Use DFS]

- We have to go upto the node where conflict has occurred.

$$3 = G | R | a | a | B$$

Not give blue due to constraint [value is empty then use Backtracking]
 Add B to domain
 then use Backtracking]

Beam Search

= =

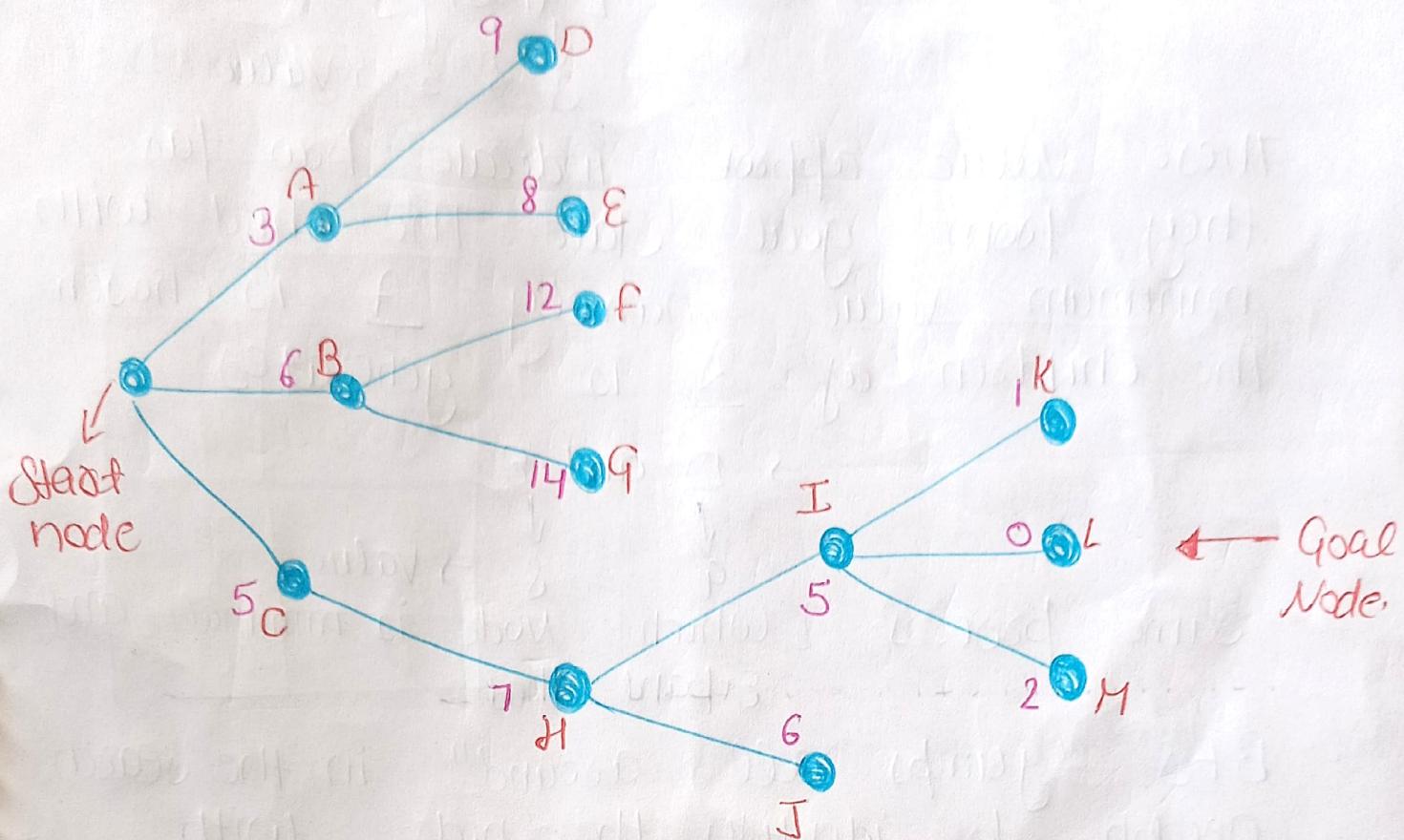
- Searching algorithm used to find shortest path which uses distance as a heuristic
- This search procedure is an evaluation-function variant of breadth-first search.
- The heuristic function used here called **evaluation function** is an indicator of how far the node is from the goal node. $f(n) = h(n)$ $O(bd+1)$, $O(bd)$

⇒ Algorithm

heuristic function [Goal node] have an evaluating function value of zero.

- Step 1: Put the initial node on a list **START**.
- Step 2: If (**START** is empty) or (**START** = Goal) terminate with success
- Step 3: Remove the first node from **START** Call them node a.
- Step 4: If (a = Goal) terminate with success.
- Step 5: Else if node a has successors, generate all of them. find out how far they are from goal state. Sort all the children generated so far [by the remaining distance from the goal. and add them to beginning of **START**].
- Step 6: Name this list as **START 1**.
- Step 7: Replace **START** with **START 1**
- Step 8: Goto Step 2.

\Rightarrow B.F.S is explained using a Search graph



Steps	Node being Expanded	Children	Available Node	Node chosen
1	S	(A:3), (B:6) (C:5)	(A:3), (B:6), (C:5)	(A:3)
2	A	(D:9), (E:8)	(B:6), (C:5), (D:9), (E:8)	(C:5)
3	C	(H:7)	(B:6), (D:9), (E:8), (H:7)	(B:6)
4	B	(F:12), (G:14)	(D:9), (E:8), (H:7), (F:12), (G:14)	(H:7)
5	H	(I:5), (J:6)	(D:9), (E:8), (F:12), (G:14), (I:5), (J:6)	(I:5)
6	I	(K:1), (L:0) (M:2)	(D:9), (E:8), (F:12), (G:14), (J:6), (K:1), (L:0), (M:2)	Search stop as goal is reached

- first , the start node S is expanded.
→ 3 children [A, B, C]

$$\begin{matrix} \downarrow & \downarrow & \downarrow \\ 3 & 6 & 5 \end{matrix} \rightarrow \text{Value.}$$
- These value appear indicate how far they from goal state. The child with minimum value namely A is chosen.
- The children of A is generated

$$\begin{matrix} \rightarrow D \text{ and } E \\ \downarrow & \downarrow \\ 9 & 8 \end{matrix} \rightarrow \text{Value.}$$
- same process. [Which Node is minimal and Expand that.]
- BFS "jumps all around" in the search graph to identify the node with minimal evaluation function value.

- A^∞ Algorithm → to find the shortest path from a starting point to a goal point.
 - Used in online, gaming and Maps.
 - based on heuristic properties
 - minimize based.
- If it is possible for one to obtain the evaluation function values and the cost function value. then A^∞ Algo can be used.
- The sum of evaluation function value and cost along path called fitness number.

$$f(n) = g(n) + h(n)$$

fitness number

↓

Estimated cost of cheapest soln

↓

Cost of particular node from the start node.

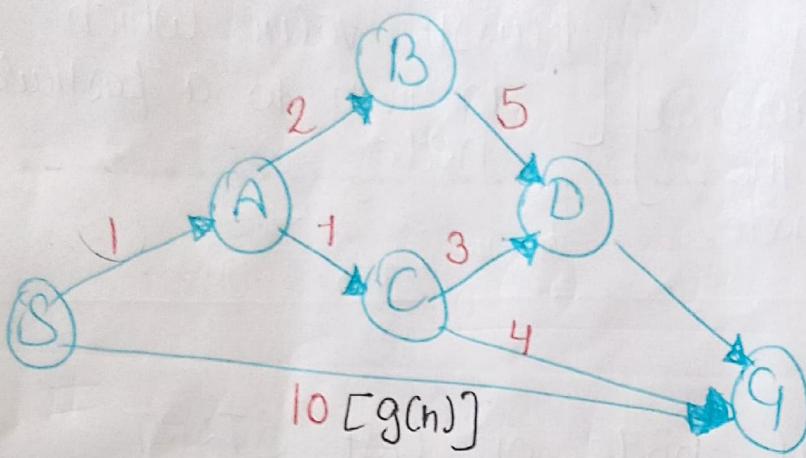
heuristic value which is given to a particular node.
from one node to goal

⇒ Algorithm

- Step 1: Put the initial node on list START
- Step 2: If CSTART is empty) or $\text{CSTART} \neq \text{Goal}$)
= terminate with success.
- Step 3: Remove the first node from START Call them Node A.
- Step 4: If $(a = \text{Goal})$ terminate search with success
- Step 5: Else if node a has successors, generate all of them. Estimate the fitness number of the successors by totaling the evaluation function value and the cost function value. Sort the list by fitness numbers.
- Step 6: Name the new list as START1
- Step 7: Replace START with START1
- Step 8: Go to Step 2.

- Time Complexity : $O(b^{1/d})$ → depth of solⁿ
branching factor
- Space Complexity : $O(b^d)$

Ex: The heuristic value of all States is given. We can calculate $f(n)$ of each state using $f(n) = g(n) + h(n)$



State	$h(n)$
S	5
A	3
B	4
C	2
D	6
G	0

SOLⁿ: # Iteration: 1

$$S \rightarrow A = g(n) + h(n) = 1 + 3 = \boxed{4}$$

$$S \rightarrow G = 10 + 0 = \boxed{10} \text{ hold.}$$

Iteration: 2

$$S \rightarrow A \rightarrow B = 3 + 4 = \boxed{7}$$

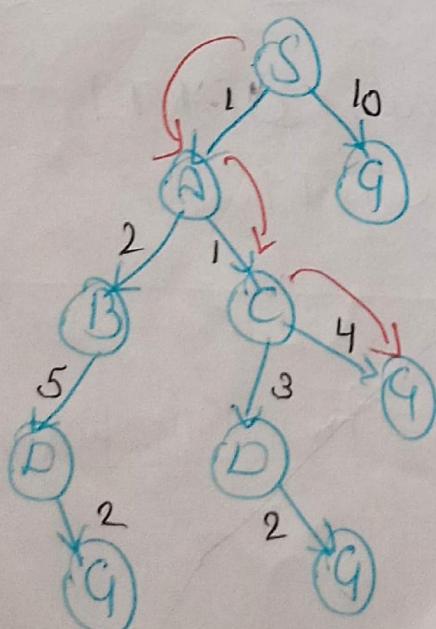
$$S \rightarrow A \rightarrow C = 2 + 2 = \boxed{4}$$

Iteration 3:

$$S \rightarrow A \rightarrow C \rightarrow D = \boxed{11}$$

$$S \rightarrow A \rightarrow C \rightarrow G = \boxed{6}$$

optimal path with cost [6].



[Branching factor finite].

- A very interesting observation about this problem is that [A* is admissible]
- If the heuristic function is admissible, then A* tree search will always find the least cost path.

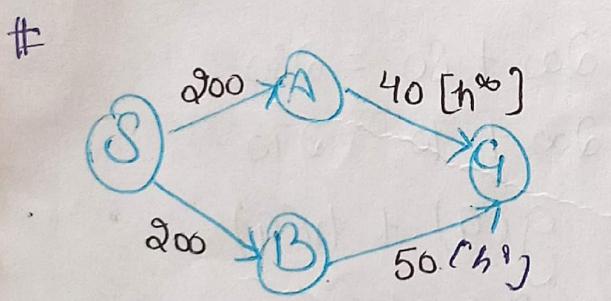
How to Proof A* is admissible

Firstly we need to understand what is "underestimation" and "overestimation".

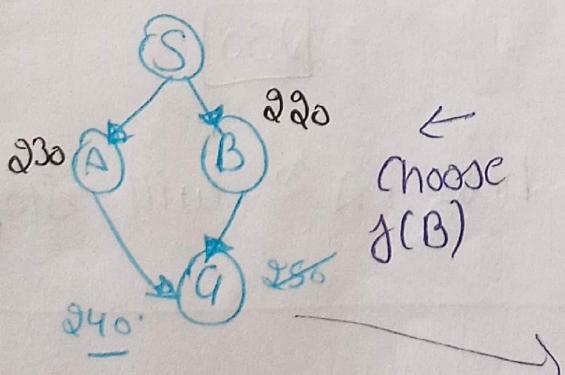
- 1) $h(n) \leq h^*(n)$ [Underestimation]
- 2) $h(n) \geq h^*(n)$ [Overestimation]

Underestimation: If the estimated value is less than actual value.

$$\begin{array}{ccc} "h(n) < h^*(n)" & & \\ \downarrow & & \downarrow \\ \text{estimated} & & \text{actual value} \end{array}$$



- $g(A) = 200$
- $g(B) = 200$
- (let $h(A) = 30$
 $h(B) = 20$)
- $f(A) = g(A) + h(A) = 200 + 30 = 230$
- $f(B) = 200 + 20 = 220$
- $f(G) = g(G) + h(G) = 250 + 0 = 250$



- but here, we will not stop, because we have a A state which has value less than $f(A)$

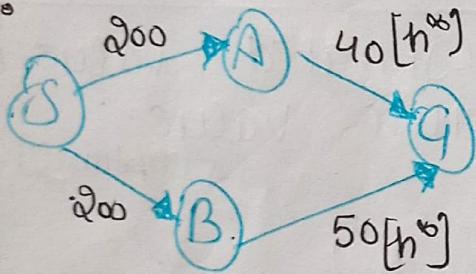
- Thus through (A)

$$f(A) = g(A) + h(A) \\ = \$40 + 0$$

$$\boxed{f(A) = \$40} \rightarrow \text{optimal answer.}$$

Overestimation: $\hat{h}(n) \geq h^*(n)$ if estimated value is more than actual value.

$$h(n) \geq h^*(n).$$



$$g(A) = \$200$$

$$g(B) = \$200$$

$$\begin{aligned} & \text{(let } h(A) = 80 \\ & \quad h(B) = 70 \text{)} > h^* \end{aligned}$$

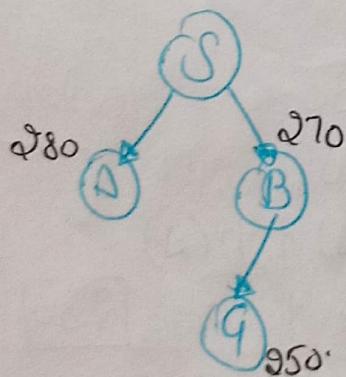
$$f(A) = \$200 + 80 = \$280$$

$$f(B) = \$200 + 70 = \$270$$

$$f(G) = g(G) + h(G)$$

$$= \$50 + 0$$

$$= \boxed{\$50}$$



- From here, A* will stop.

- ## # Advantages
- Optimal and complete
 - Use in shortest path algo
 - Solve complete problem

Disadvantage

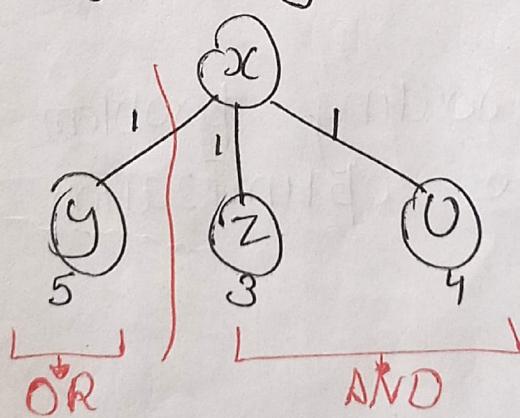
- Used extra memory as compared to BFS
- Some complexity issues.

AO[∞] Algorithm

- Heuristic search, also called knowledge based.
- AO[∞] define And-OR Search Algorithm
- AO[∞] is best fit search algo that is known as knowledge-based technique. That means the Start State and Goal State are already defined & the best path is found using the heuristics.

$$f(n) = g(n) + h(n)$$

eg:



$$\begin{aligned} \cdot f(n) &= 1+5 \\ &= [6] \end{aligned}$$

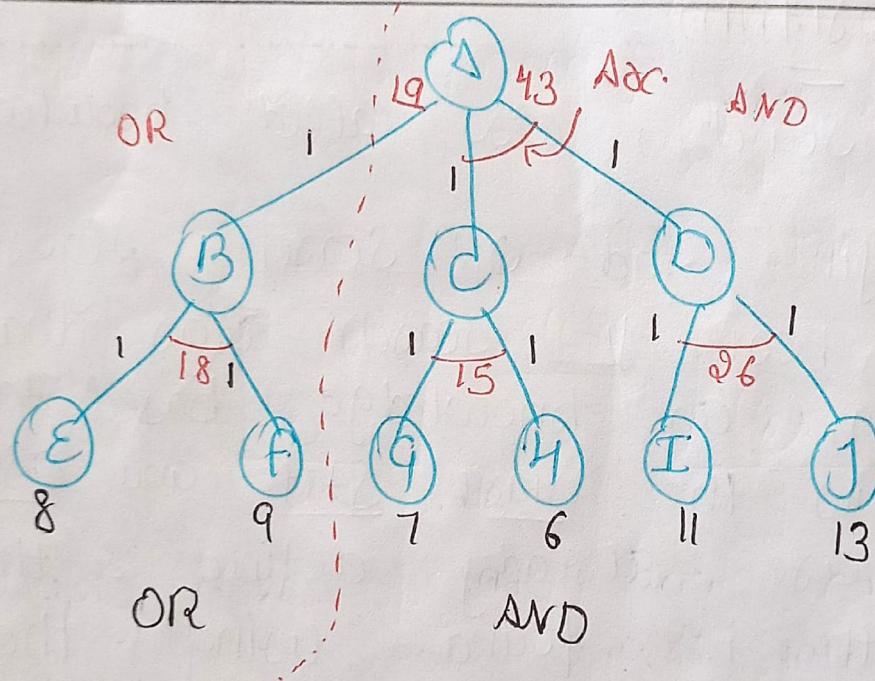
$$\begin{aligned} f(n) &= 1+3+1+4 \\ &= [9] \end{aligned}$$

- Work on Problem decomposition
- It uses the concept of AND-OR graphs to decompose the complex problem into a set of sub-problems to reach at the goal state.

AND: Set of tasks that are done to be reached to goal state.

OR: The different way that can be taken to reached to goal state.

Ex:



Application

- Vehicle routing problem
- Portfolio optimization.

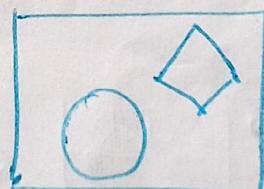
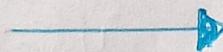
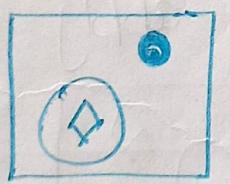
Mean - End - Analysis

- Mean - End - analysis is problem - solving techniques used in Artificial intelligence for limiting search in AI Programs.
- It is a mixture of Backward & forward search technique.
- 1961, Allen Newell.
- The MEA analysis process b/w the current state & goal state.

How it works

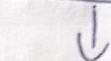
- first, evaluate the difference b/w initial state and final state
- Select the various operators which can be applied to each difference.
- Apply the operators at each difference, which reduce the difference b/w the current state and goal state.

Ex:-



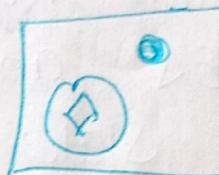
- In this problem, we need to get the goal state by finding differ b/w initial state & goal state and applying operators.

Sol: first generate a new State and apply operators



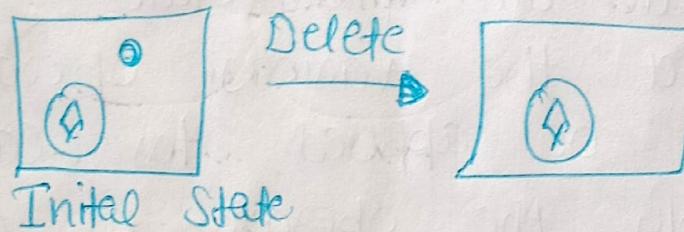
- Move
- Delete
- Expand

1) Evaluating initial state:

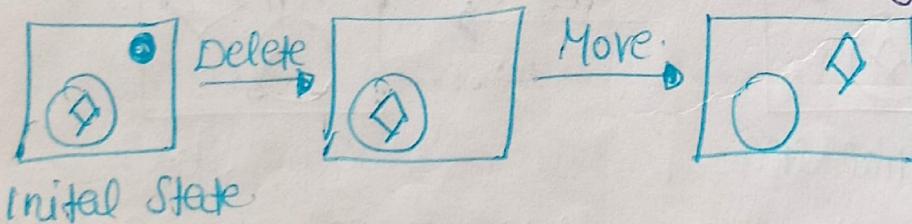


initial state.

2) Apply operators [Delete]: first remove this dot because in goal state no dot symbol.



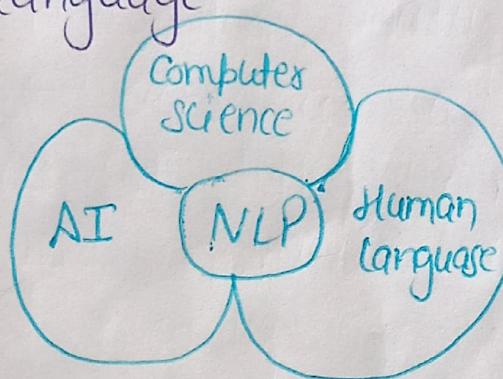
3) Apply Move operator: again compare with goal state, after square is outside the circle. i.e apply more operators



4) Apply Expand operator: after compare, one difference which is size of square, so apply Expand and finally, generated goal state

Natural language Processing

- How human communicate with each other.
- NLP is a part of computer science, Human language, and Artificial intelligence.
- It is the technology that is used by machine to understand, manipulate the human language.



- Main focus b/w computer and human through natural language.
- It started in 1940s.
- The input and output of an NLP system can be
 - Speech
 - Written Text

⇒ Goal of NLP

- Understanding language
- Text and speech recognition
- Machine Translation.
- Semantic Understanding

Need

- Human Computer interaction
- Language Understanding
- Data processing & analysis
- Speech recognition
- Sentiment analysis
- Information retrieval

Advantages

- helps to ask question about any subject and get a direct response within seconds.
- time efficient
- help computers to communicate with human in their languages.
- Most of companies use NLP to improve the efficiency of documentation, accuracy and identify the information

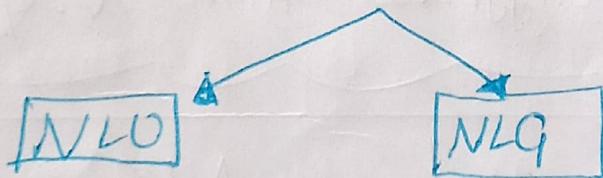
Disadvantages

- NLP may not show context
- NLP is unpredictable
- May require more resources

lock of understanding
complexity
ambiguity
Paraphrasing
Slang

Components of NLP

- These are the following two components of NLP.



- NLU :- Stands for "Natural language Understanding".

- It helps the machine to understand and analyse human language by extracting the metadata from content such as concepts, entities, keywords, emotion, relations and semantic roles.

- NLP mainly used in **Business application** to understand the customers problem in both Spoken and written language.

→ NLU involves the following tasks

- It used to map the given input into useful representation
- It used to analyze different aspects of the language.

②) **NLG**:

= Stands for "Natural language Generation".

- It acts as a translator that converts the computerized data into natural language representation.
- It mainly involves Text planning, Sentence planning.

NLU is difficult than NLG

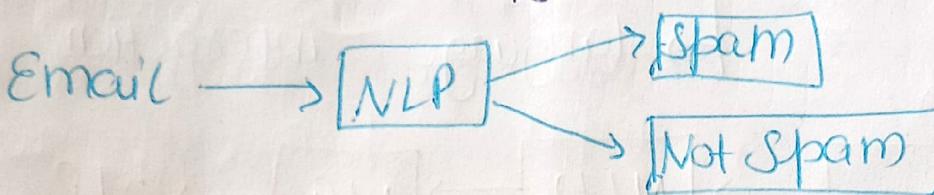
#

NLU

- It is the process of reading and interpreting language
- It produces non-linguistic outputs from natural language inputs

NLG

- NLG is the process of writing or generating language.
- It produces constructed natural language output from non-linguistic inputs.

- # # Application of NLP
- 1) Question Answering : that automatically answers the question asked by human in a natural language
eg: Alexa.
 - 2) Spam Detection : it is used to detect unwanted e-mails getting to a user's inbox.


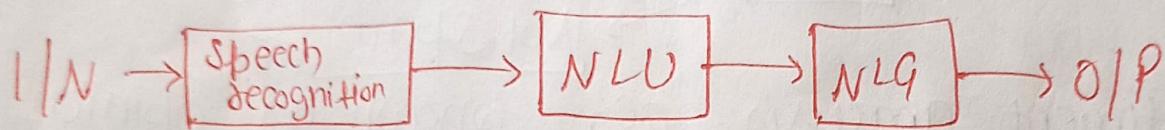
```
graph LR; Email[Email] --> NLP[NLP]; NLP --> Spam[Spam]; NLP --> NotSpam[Not Spam]
```
 - 3) Sentiment analysis : also known as opinion mining. define combination of NLP and identify the mood of content.

 - 4) Machine Translation : used to translate text or speech from one natural language to another natural language
eg: Google Translator
English → Hindi
 - 5) Spelling Correction : Microsoft Corporation provides word processor software like MS-Word.
 - 6) Speech recognition
 - 7) Chatbot

Working of NLP

- It typically involves using computational technique to analyze and understand human language.
- They include tasks such as:

→ language understanding
→ language generation
→ language interaction.



- Speech recognition:- The translation of Spoken language into text.
- NLU: The computer ability to understand what we say.
- NLG: The generation of natural language by a computer
- NLU & NLG are key aspects during the working of NLP devices.

Technologies

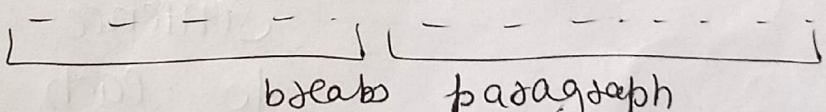
- Tokenization
- Part of Speech Tagging
- Machine learning
- NLP, TTS, STT

NLP Pipeline

- An NLP pipeline refers to a series of steps or process that are used to analyze and understand natural language text or speech data.
- These pipelines are designed to transform unstructured human language into a structured format that can be processed and analyzed by computers.
- Each step in pipeline serves a specific purpose in the NLP task, and the output of one step becomes the input for the next.

→ How to build an NLP pipeline

1) Sentence Segmentation: It is first step for building the NLP pipeline. It breaks the paragraph into separate sentences.

Eg:  breaks paragraph

2) Word Tokenization: It is used to break the sentence into separate words.

Eg: It offers Summer Training

→ Word Tokenizes:

"It", "offers", "Summer", "Training"

3) Stemming :- It is used to normalize word into its base or root form

e.g.: Celebrates, Celebrated and Celebrating all are originated with single root word "celebrate".

→ Problem: Not have any meaning [root word]

4) Lemmatization :- Similar to stemming used to group different inflected forms of word which has a meaning of root word.

5) Identifying Stop Words: In English, there are a lot of words that appear very frequently like "is", "and".

6) Dependency Parsing :- It is used to find that how all the words in the sentence are related to each other.

7) Pos tags: Stands for part of speech, which includes Noun, Verb, Adverb.

• indicates that how a word function with its meaning as well as grammatically.

→ "Google" → verb.

8) Named Entity Recognition: process of detecting the named entity such as person / name.

9) Chunking: It is used to collect the individual piece of information and grouping them into bigger pieces of sentences.

Phases of NLP

1) Lexical analysis: involves identifying and analyzing the structure of words.
• It divides the whole text into paragraphs, sentences.

2) Syntactic analysis: used to check grammars, word arrangements and shows the relationship among the words.

Eg: Agaa goes to Poonam
→ Not sense, rejected by SA.

3) Semantic analysis: draws the exact meaning from the text.
• Done by mapping

4) Discourse integration: depends upon the sentence that proceed it. also involves the meaning of sentences

5) Pragmatic Analysis : It helps you to discover the intended effect by applying a set of rules.

Problem with NLP

NLP is difficult because Ambiguity and Uncertainty exist in the language.

→ Ambiguity :
With words and phrases can have multiple meaning based on context.

• Lexical : exists in presence of two or more possible meaning of sentence within a single word.

e.g.: MANxa is looking for Match

• Syntactic : Two more possible meaning within sentence.

• Referential : When you are referring to something using pronoun.

→ Solⁿ : Implement algo and consider context that considers the surrounding context to disambiguate

→ Lack of Contextual awareness

= To understand

any word is crucial for accurate info.

Solⁿ: Develop Models

- AI researchers use various techniques where models are trained on amount of text data to recognize patterns and understand language structure.
 - These Models learn how words are used in different contexts, allowing them to make more accurate predictions.
- Subjective language → with different expressions.
- Solⁿ: By using Models, can better respond and understand.

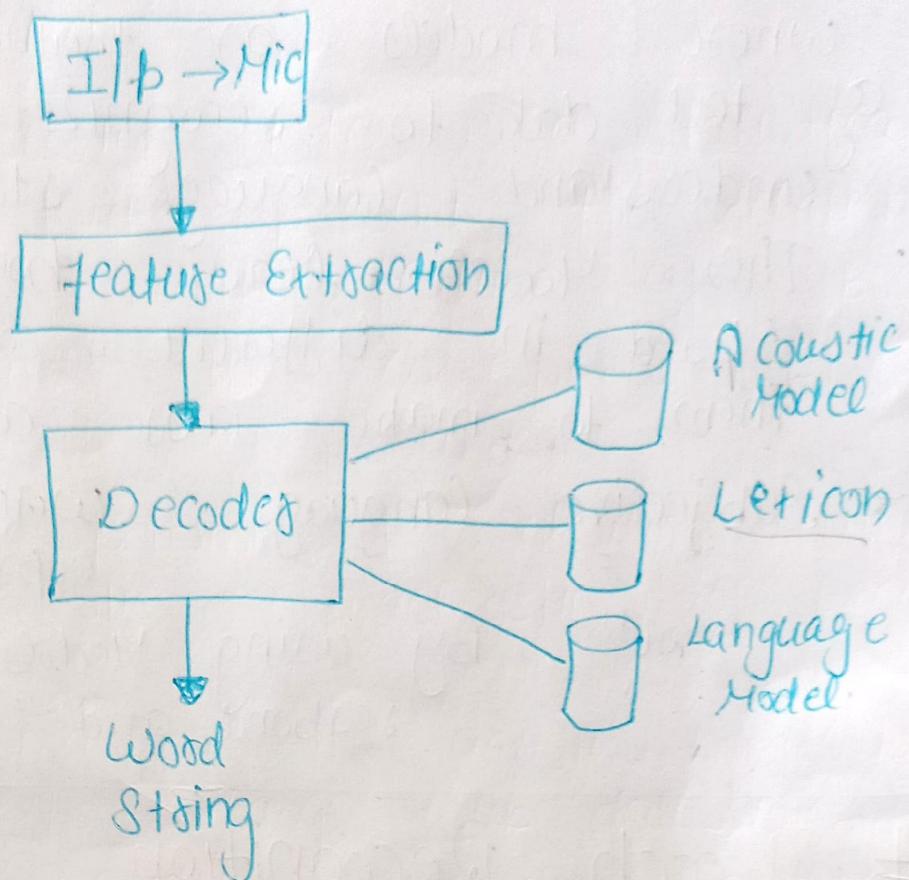
Speech Recognition

- also known as automatic speech recognition
- It is a technology that converts spoken language into written text.
- It is a crucial component in various applications, such as voice assistant, transcription services.

=> Advantages

- Natural interaction
- Hands-free operation
- Multitasking
- Improved user interface.
- Accessibility.

\Rightarrow Speech Recognition Model



- 1) Input Audio: Speech recognition starts with an audio input, which is typically captured through a microphone.
- 2) Preprocessing: The audio signal undergoes preprocessing to remove noise, enhance the quality of speech and separate it from other sounds in the environment.
- 3) Feature Extraction: The system extracts relevant features from audio, such as the frequency, pitch of different sounds.

4) Acoustic Modeling: Speech Recognition System
= use Acoustic models, which are statistical models that has been trained as large datasets of spoken language

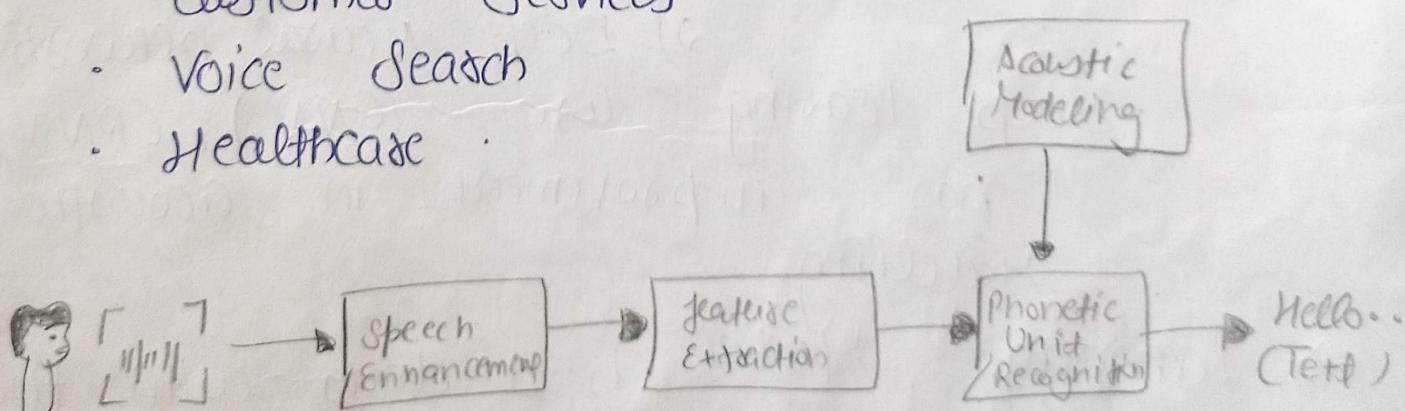
5) Language Modeling: In addition to acoustic model language models are used to consider sound are matched with word sequence, the likelihood of word sequence in given language.

6) Decoding: During the decoding process, the system analyzes the audio signal and using the acoustic and language models.

7) Text output: The final output is the recognized text.

Application of Speech recognition

- Virtual assistants
- Transaction Services
- Customer Services
- Voice Search
- Healthcare



analyze the audio

- break it into parts
- digitize it into a computer - readable format.
- Use an algo to Match it to text database.

Approaches of Speech recognition

→ Acoustic Model

The Acoustic Model is a statistical model that represents the relationship between the acoustic features of speech signal and the corresponding phonemes (basic unit of sound).

- Mainly responsible for dealing with the acoustic characteristics of speech signals.
- During Training, the acoustic model is exposed to large sub-dataset containing pairs of audio recording and their corresponding transcriptions.
- It learns to map the acoustic feature of audio signal to phonemes or sub-word units.

→ Common techniques

- 1) Hidden Markov Model.
- 2) Deep Neural network.
- Deep learning uses (CNN), (RNN) has improvement in acoustic modeling.

→ Language Model

- 1) It deals with the linguistic aspects of spoken words.

- It responsible for predicting the likelihood of a sequence of words occurring in particular order it helps in improving the accuracy of the transcription by considering the context of words.
- N-gram models, Hidden Markov Model and more recently Model are used in.
- Dictionary and Pronunciation Model
- feature Extraction.

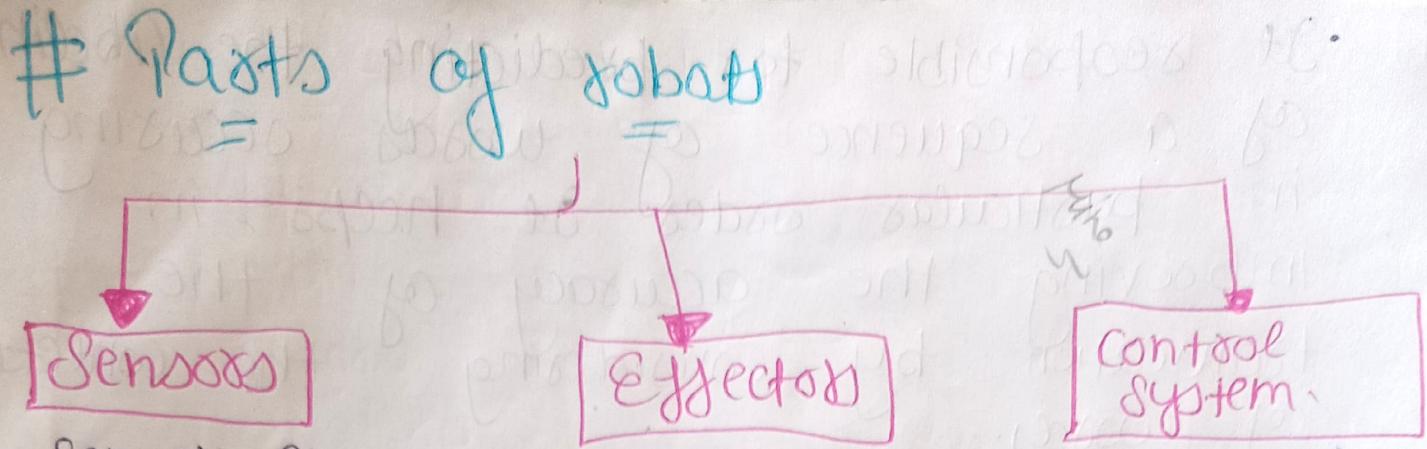
Robots

Adv: Increased Safety, Efficiency
Dis: Improved Accuracy
Dis: Initial Cost, Job losses.

- A pre-programmed machine designed to complete a task.
- A robot is a machine that looks like a human, and is capable of performing out of bot action and replicating certain human movements automatically by means of command given to it using programming.
- Drug Compounding Robot
- Automotive Industry robots.

→ Types of robots

- ROV Guided
- AV (Automatic Vehicle)
- AMR (Automated Mobile Robot)
 - Humanoid robot
 - Cobots



- Sensors are what allow a robot to gather information about its environment.
- It serves as the eyes and ear of a robot.

Ex: touch Sensors,
Camera

Effectors

- The effectors are the parts of the robot that actually do the work.

• End effectors

Control system

- 'brains'
- A robots Control Syst is that part of robot that determines the robot behaviour

Controlling a robot

Control System
Programs
Sensor
Actuator
Control algo.
Remote control

- AI robots are controlled by AI programs and use different technologies of AI machine learning, computer vision.
- NLP can be used to give voice command to AI robots. It creates a strong human - robot interaction.
- Through NLP technique, the robot can understand and reproduce human language.

Programming ; Actuator,
Control system, Sensor,
Human-computer interaction.

Components of Robot

- Actuators: are the devices that are responsible for moving and controlling a system or machine.
 - helps achieve physical movements
- Power supply: It is electrical device that supplies electrical power to an electrical load.
 - electrical current → power load.
- End effectors: Basically means the joints and links b/w known as End effectors. The device which connects the arms of robots.
- Locomotive Device: which are responsible to move the robot in any direction in dependent
- Controllers: Basically means the computer or the Brain of Robots.
 - Combinations of hardware and software control the different activities of the robots.
- Sensors: They provide the ability like see, hear, touch and movement like humans.

Characteristics of Robot

- Appearance [hold the structure of body]
- Brain
- Sensors [gather info]
- Actuators [Robot move and fast with help]
- Program [work on instructions]
- Behaviour [autonomy]

Application of Robotics

- In defence sectors
- Robotics in medical sectors
- Robotics in industrial sector
- Robotics in Entertainment
- Robotics in mining industry

Technology Used

- Computer Vision
- Natural language processing
- Edge Computing
- Transfer learning and AI.
- Reinforcement Learning [feedback-based learning method]

AI Program

- They usually operate in computer-stimulated worlds
- They need general purpose computers to operate on.

Robot

- They operate in real physical world
- They need special hardware with sensors and effectors.

- # # Robotics
- It is the branch of AI which totally focus on the design of the robots known as robotics.
 - That helps the creation of intelligent machine.
 - Combination of Electrical engineering, Mechanical engineering and computer science.

⇒ Three principle of Robotics given by Isaac's Asimov

- Robots will never harm human beings
- Robots will follow instruction given by human without breaking law one
- Robots will protect themselves without breaking other rules

Intelligent Robot

- It is a machine that can performs tasks and make decision on its own, without constant human guidance.
- It combines robotics (the physical body) with artificial intelligence (the ability to think & learn).

Features

- Learning capability
- Perception
- Decision making
- Autonomy

Eg: Self-Driving Car

- Vaccum Cleans.

Mobile Robot

A mobile robot is a type of robot that can move from one place to another.

- They use special sensors and computer smarts to understand where they are and where they should go.

Type:

- 1) Autonomous
- 2) Non-autonomous

feature:

- Mobility
- Navigation
- Sensors

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Eg: Delivery robots.

Classification

- Based on environment in which they work.
→ Aerial, Land or Home robots
- Based on device they use to work
→ Wheeled, Humanoid