Artificial Intelligence

[John McCarthy]

- Artificial intelligence is composed of two words Artifical and Intelligence
  - Artifical → "Man-made"
  - Intelligence → "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, resoning and solving problems.

⇒ Why we learn AI

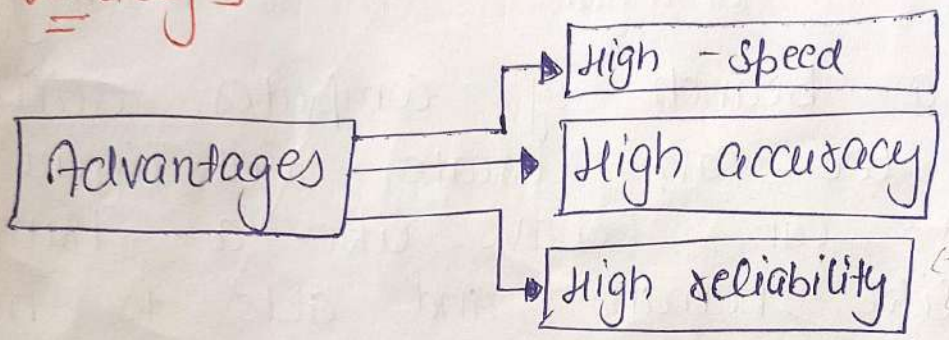
- With the help of AI, we can create such software which can solve real-world problems.
- can create person virtual assistant.
- can build such robots.

Develop code and perform task.

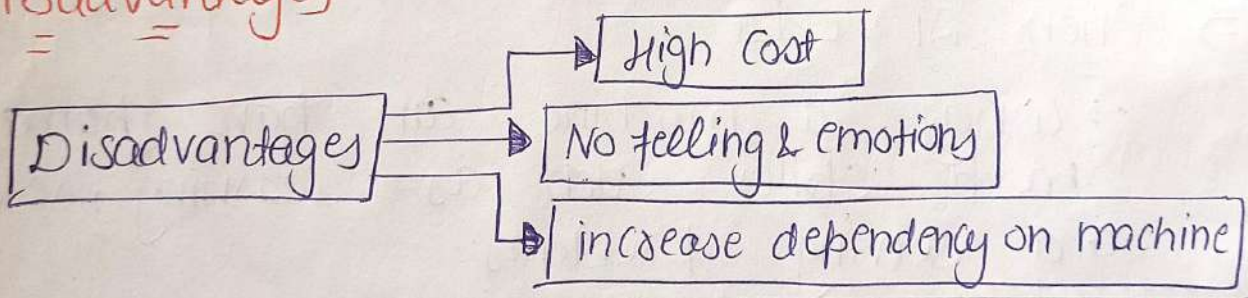
Goals

- 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

- Reasoning [logic, rule]
- Branching [choosing different paths]
- Selection [" " option] based on certain condn
- Reduce human effort → efficiency
- Looping or repeating
- Learning. → Supervised → Un-
- Facial recognitions → verify & identify

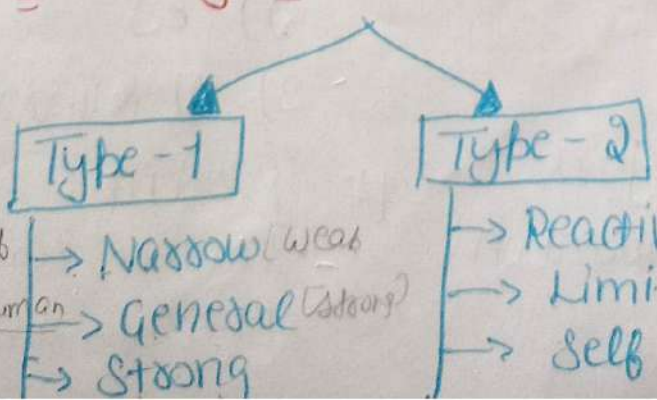
Application of AI

- It is becoming essential for today's time because it can solve complex problem.
- AI in astronomy: It can useful to solve complex universe problems.
- AI in Healthcare: AI can help doctors with diagnoses, can inform when patients are worsening.
- AI in Gaming: AI machine can play strategic games like chess,
- AI in finance: machine learning into financial process.
- AI in education: 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 color etc.

- AI in Robotics
- AI in Agriculture

Types of AI

- Based on capabilities
- Based on functionality



History of AI

- Maturation of Artifical intelligence
  [1943 - 1952]
- The birth of Artifical intelligence
  [1952 - 1956]
- The golden year - Easly enthusiasm
  [1956 - 1974]
- The first AI winter
  [1974 - 1980]
- A boom of AI
  [1980 - 1987]
- 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, reasoning 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.

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knowledge → awareness and understanding derive facts, data and situation from experiences

- 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 pictorized

⇒ Type of knowledge

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

   eg:→ The captial of Paris.

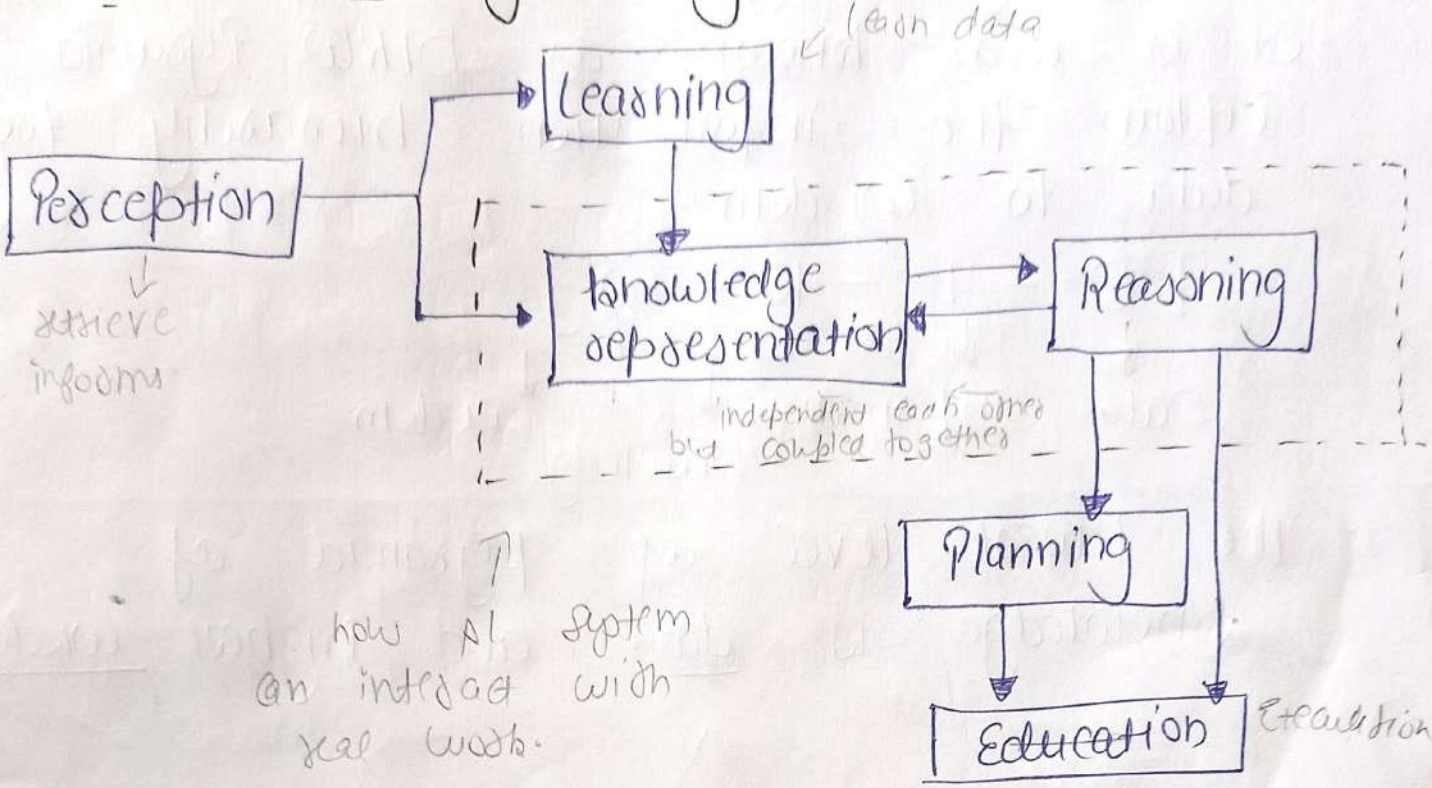
2) **Procedural knowledge:** which is responsible for knowing how to do something.
   - also known imperative knowledge.
   - include rules, strategies

3) **Meta knowledge:** knowledge about the other type of knowledge
   [helps in efficient utilization]
   - improve the performance of AI

4) **Heuristic knowledge:** representing knowledge of some experts in a field.
   [acquired by experience]
   - based on past 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.

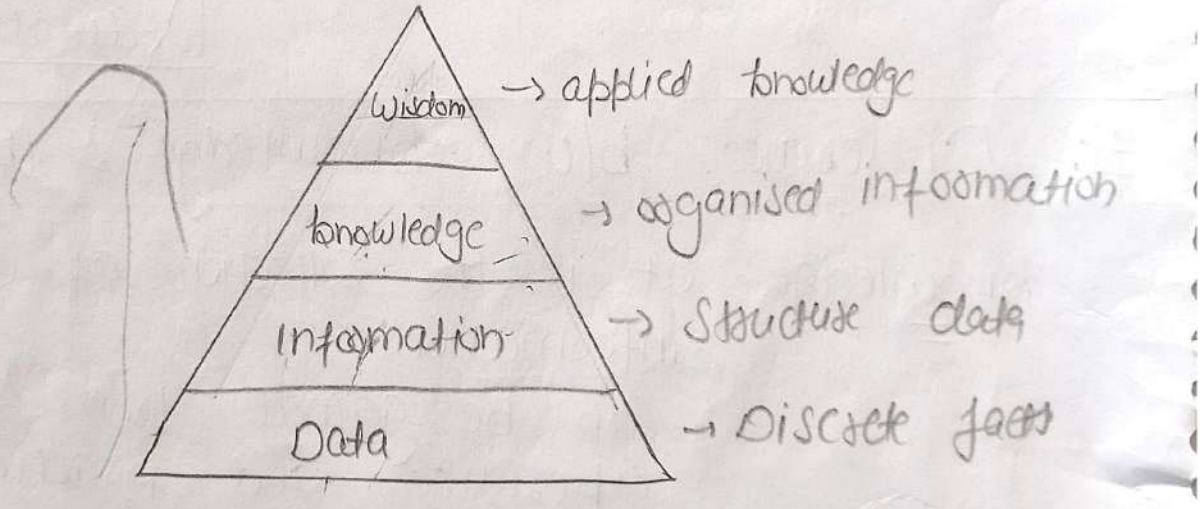
Knowledge Pyramid

- It represent the hierachy of ing in AI system.
- It is also known as DIKW Pyramid explain the information hierarchy from data to wisdom.

[D - I - K - W]

Data → Information → Knowledge → 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 result of analyzing and interpreting information.
  - It provides an understanding of "How" and "Why" certain phenomena occur.

- **Information:** Is organized, structured and context data.
  - It useful for answering basic question 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

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Characteristics of AI Problems

- The problem 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 sol^n, 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

- Completity → Complex 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 reduction.

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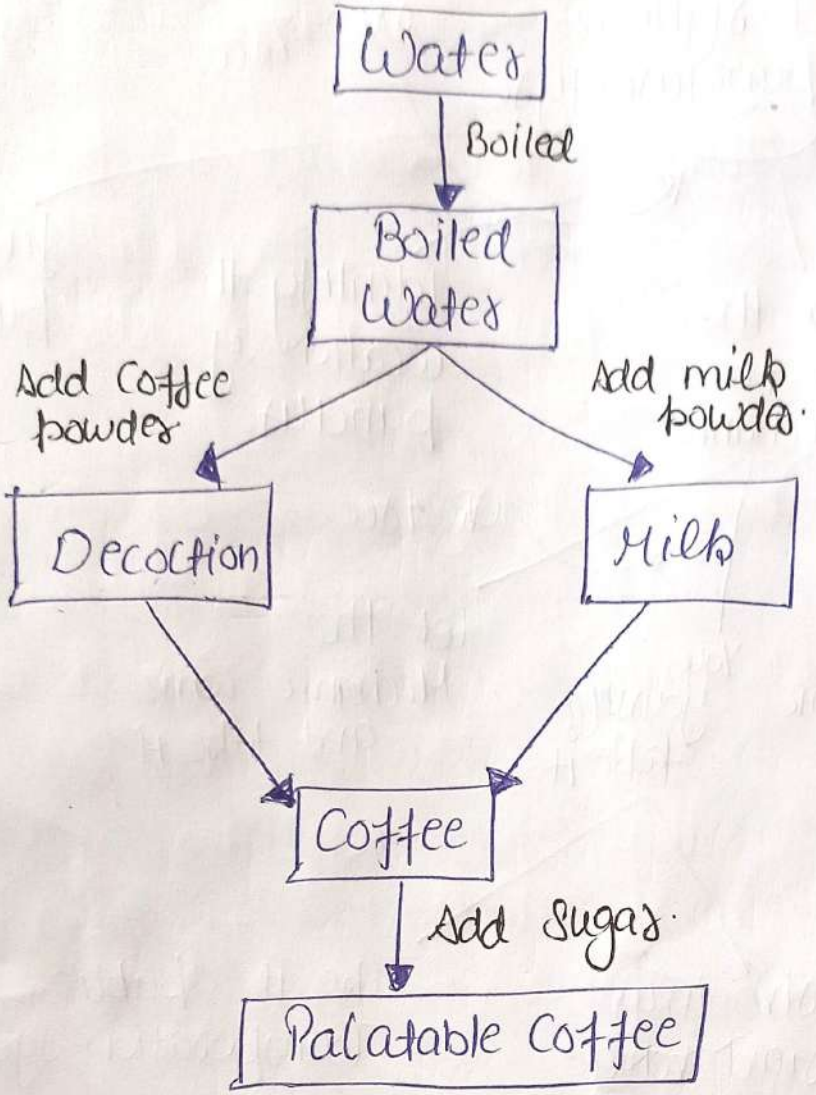
1) State Space Representation: } Set of all posible States for a given problem.
   - ↓ Condⁿ and Situation in a particular time.
   - ↳ Movement

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

□ → Node Arc → ↓ ← ↑ , S → Starting Node

Steps

- Boil necessary water in bottle.
- 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



- [integradients] [initial State]
  - Seq of steps
- [last had] a cup of coffee (goal State)
- [opesatoss] Milk, sugar powder

- easy to represent

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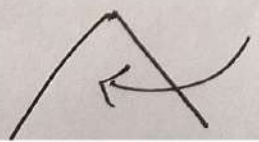
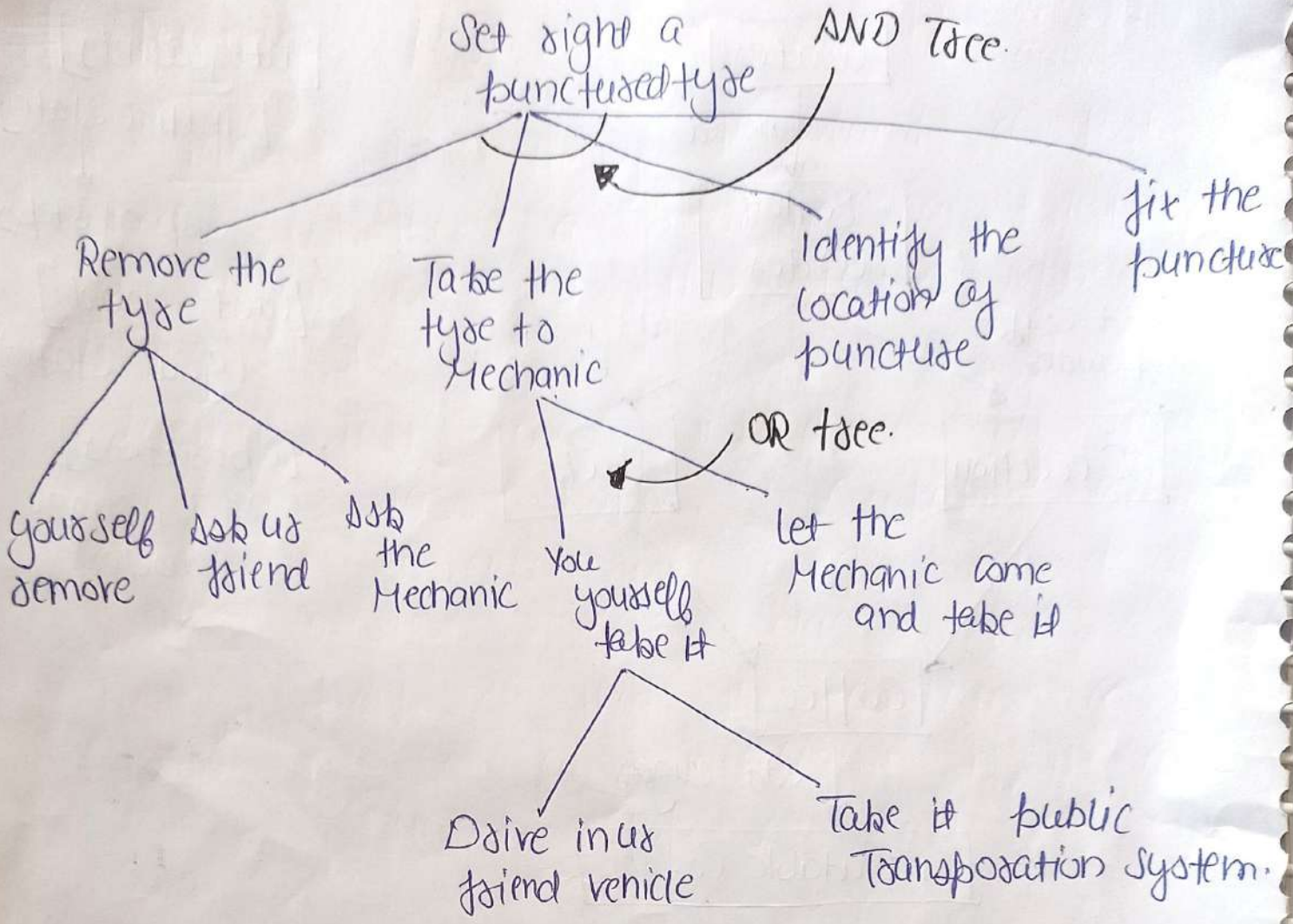
2) Problem Reduction : a large or complex problem is divided into small groups.

eg: Set right a punched tyre.

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





AND - OR Relationship

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

→ AND- Relationship: find a problem Soln.

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

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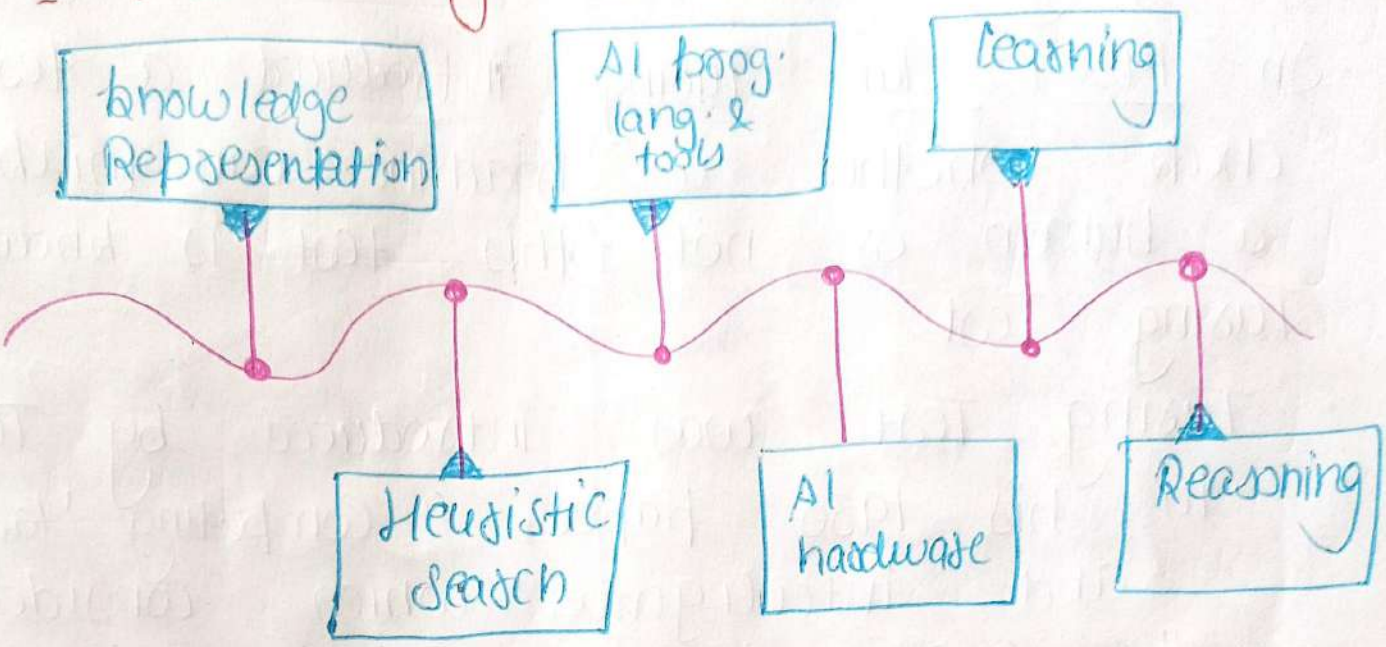
forms and Technologies of AI

- Weak AI
- Strong AI

- Machine learning
- NLP
- Robotics

Component of AI



- knowledge representation :→ It involves capturing and organizing infos. in a way that is suitable for processing.
  → logical representation

- Heuristic Search :→ which are rule of thumb.
  - Problem-solving approach designed to analyze problem and give best
  - rule or technique that guide the search process.
  → A* Algo.
  → to find soln b/w two places.

- AI hardware components: physical parts of computers that help it run AI progra.
  → GPUs
  → TPUs

- Learning: like teaching a computer to get better at something.
  Can learn data and improve their performance overtime.

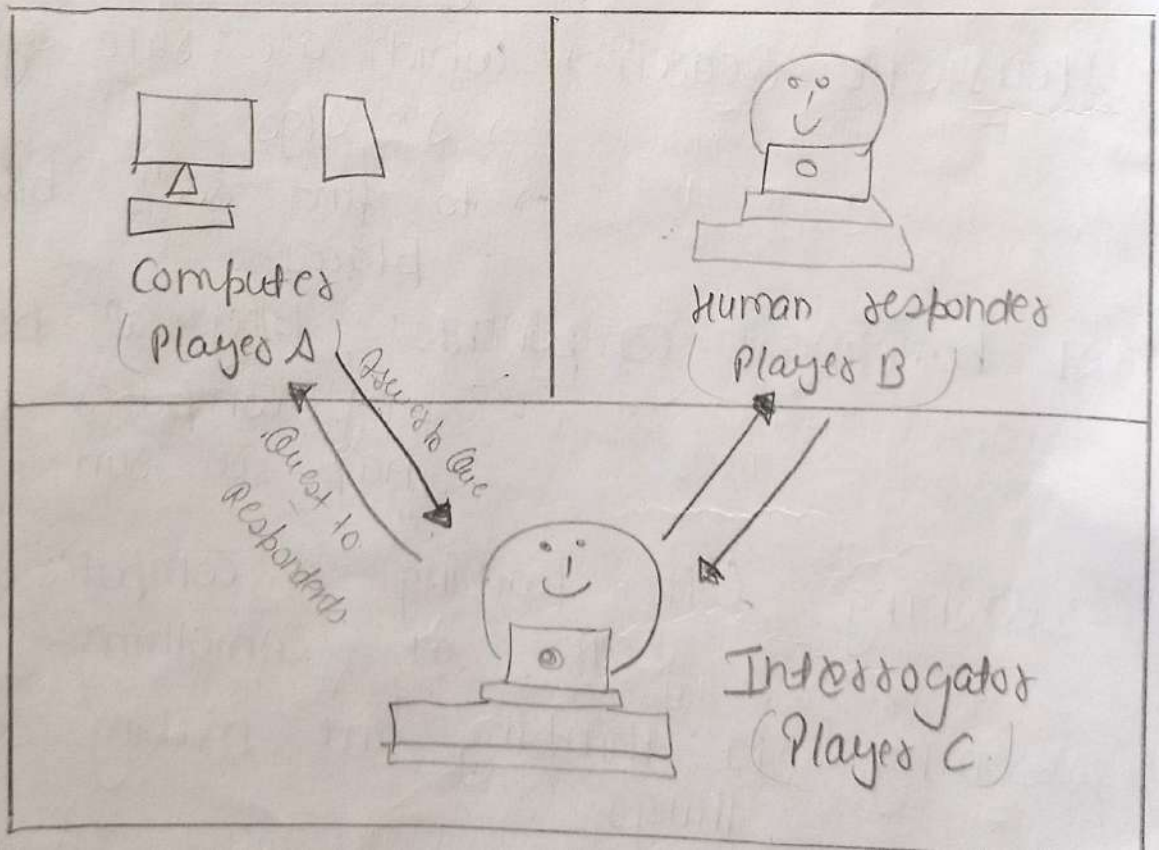
- Reasoning: is thinking and making sense of things.
  - to make logical and draw conclusion based on available information

[NLP]
[R

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 condⁿ.



- Turning 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

Humain

- Use brain powes
- Basic unit is neuron.
- Has emotions
- Has the capacity to learn.
- Has self-awasness.
- Accuracy → can make mistakes
- Decision → can make their own decision
- Storage. Human may forget what they have learned and Stored in their mind.

Computes

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

Expert Systems

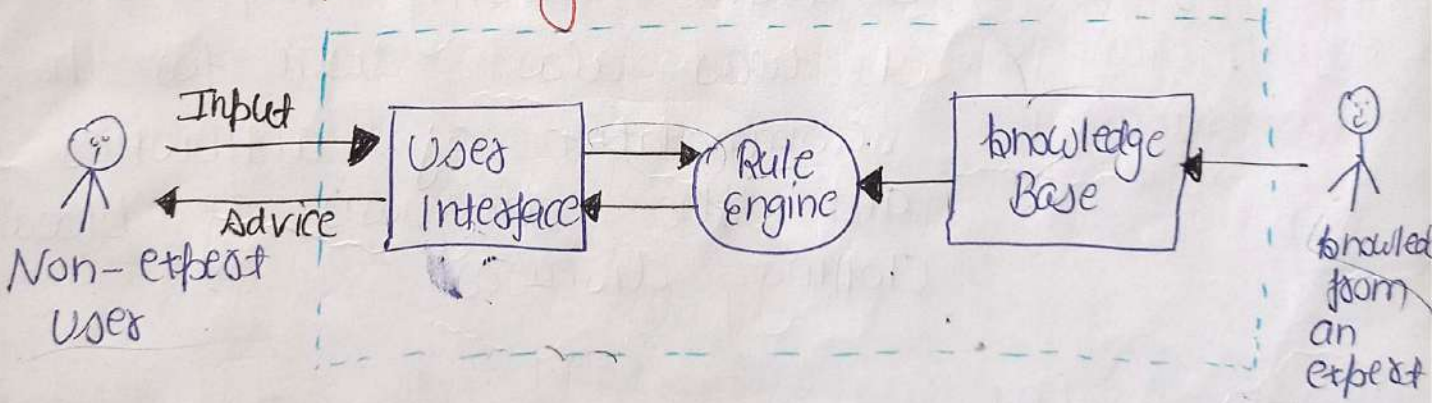
ability to make decision

terms 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 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 artifical intelligence project that was made as a 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) MYCIN :-

↓

Developed by Stanford Onivessity. [1970]

English equivalent

IF → sit of infect

AND → site of culture

AND

Then

Domain :→ Medicine

function :→ Diagnosis.

- It was one of earliest backward chaining expert system that was designed to find the bacteria causing infection.
- It was also used for the recommedation of antibiotics and the diagnosis of blood clotting diseases.

3) XCON/R1 :-

Domain :→ Computer System Configur

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 complex problem of a specific domain with accuracy.
speed

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

Good → Reliable: much reliable for generating an efficient and accurate output [without any 5% ↓ work]
Consistency → Not work continuity, work on Moment

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

- Learning Capability: ↓ any particular area skills
- Domain specificity [ability of syst to perform tasks]
- High efficiency

→ Data: Deals with uncertain and irrelevant data.

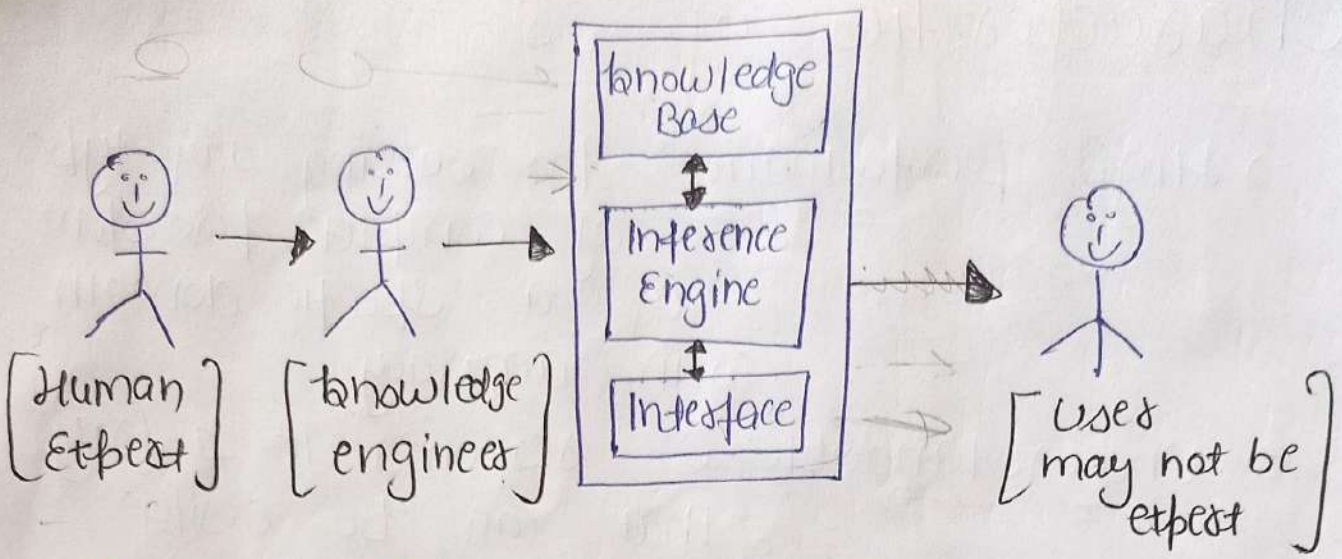
Components of Expert System

An expert system mainly consist of three components.

- User interface
- Inference Engine
- Knowledge Base

about event, object, task-performance ↓

- Domain-specific: deal with all kind of knowledge about a particular domain.
- Common-sense: → increas performance of system.



- **Human expert**: Who have the knowledge of specific domain expert
  - Domain specific knowledge
  - Common-sense "
- **knowledge engineer**: a person who have the knowledge of computer
  - Who gather the knowledge from domain experts.
  - → factual
  - → Heuristic Based.
- **Uses - 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 uses.
  - In other words, it is an interface that helps a non-expert users to communicate with the expert system to find a solution.

Inference Engine :)

(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 desire a conclusion, new information deduce.
- With the help of IE, the system extracts the knowledge from the knowledge base.

Deterministic [based on [assumbed to be true.]
[based on facts & rule]
↓
[based on rule IF-Then]

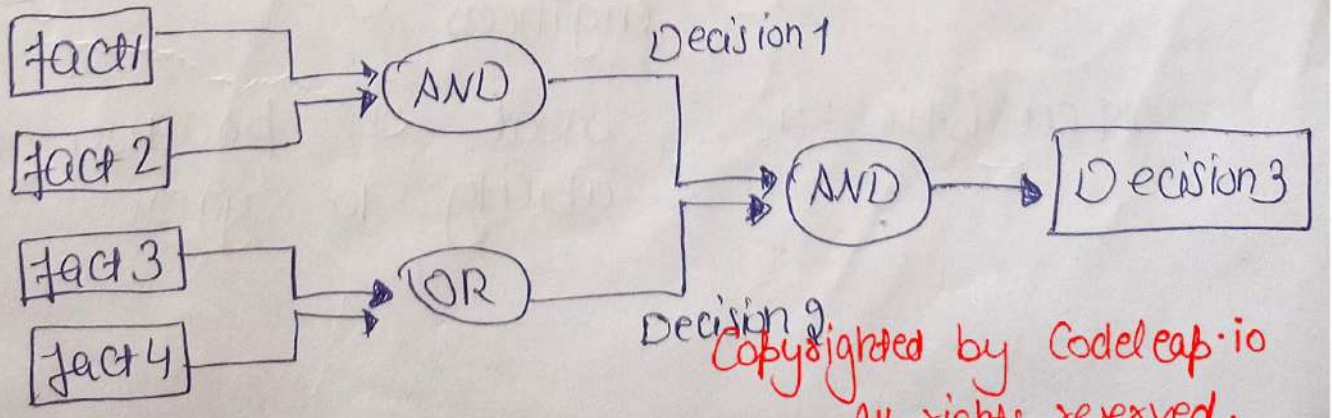
Probabilistic [based on probably]

⇒ Approaches of IE

- Forward Chaining
- Backward Chaining

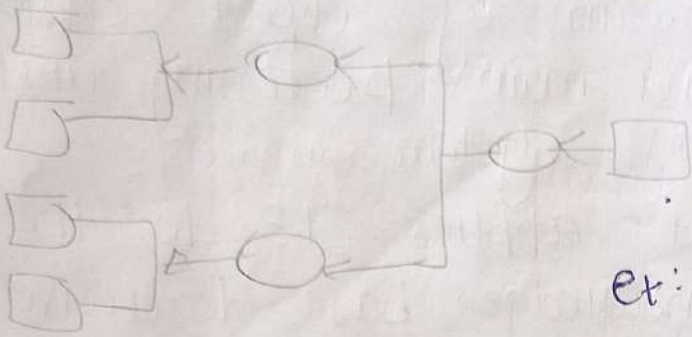
- Forward Chaining :) also known as data-driven search.
  - It starts from the known [facts & rules]
  - [What will happen Next]

[IF cond^n Match]



- Backward Chaining :-

[Then Cond^n]



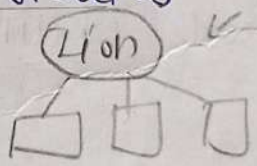
also known as Consequent driven search.
- that start from the goal and work backward to prove the facts.
- "why this was happend"

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

Advantages

- Accuracy
- Multible expert
- Maintence
- Development of increase accessibility.
- High speed to respond query
- Scalability
- High reliability

Limitations

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

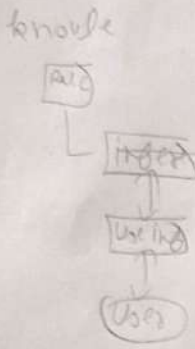
Applications

- In designing and manufacturing domain.
- Medical → Diagnosis
- Analysis
- Control
- Instruction
- Monitoring
- Planning
- finance
- Education
- Customer Support
- Agriculture

Features

Categories of Expert System

- Rule - Based
- frame - Based
- fuzzy Based
- Model Based
- Hybrid ES



apply cond'n or action

[Use frame to represent knowledge

[handle uncertainty and imprecision by using logic.

use degree of truth-use concept

suitable for domain where information in not binary.

- **Rule - Based:** [cond'n apply]
  - They use a set of explicitly defined rule to represent the knowledge of Human experts. set of rule that encode knowledge in the form of if then rule
  - [If - then] → cond'n apply

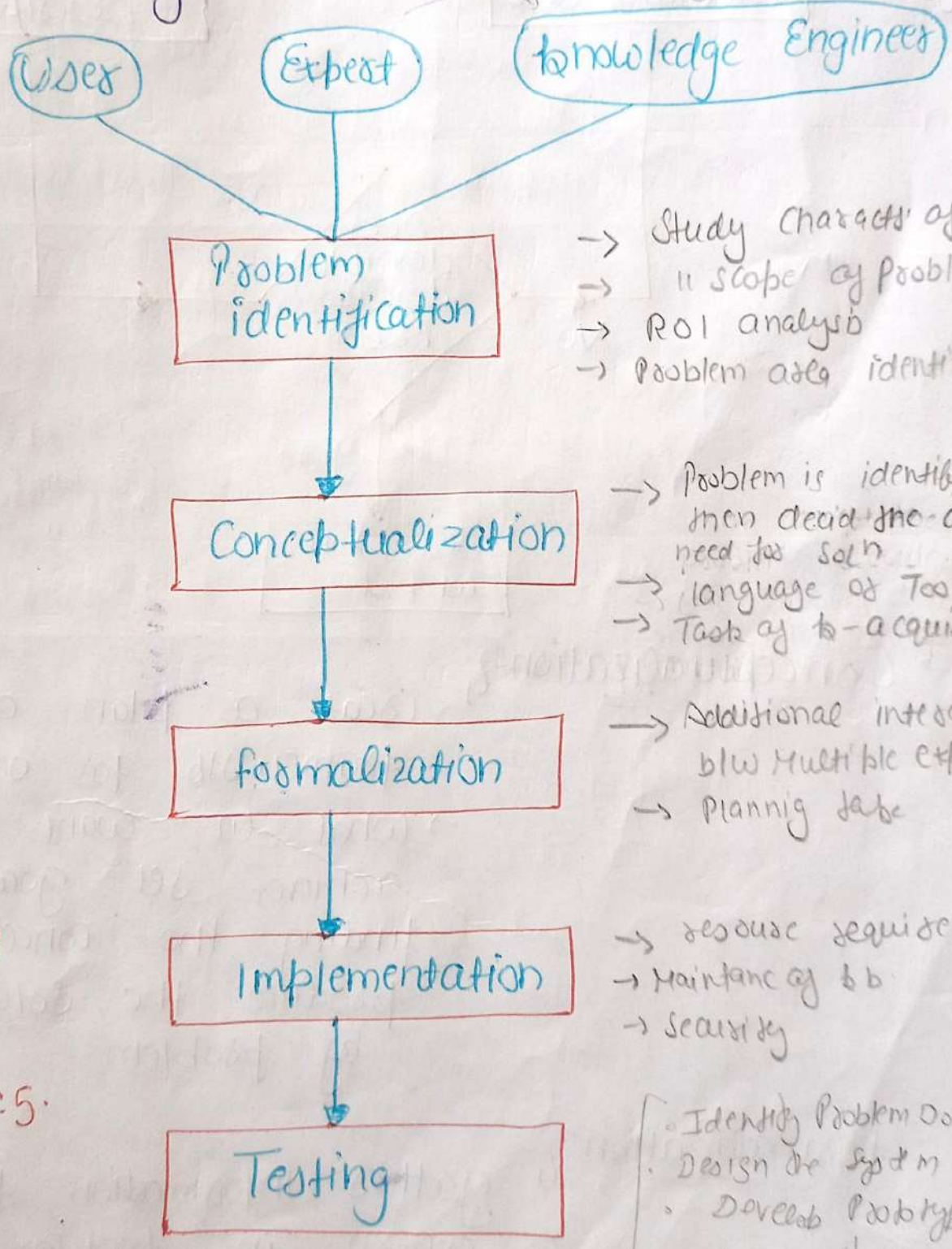
  Ex: If symptoms include fever then the diagnosis might be flu.

- **Model - Based:** It use different approach to represent knowledge.
  - It capture the relationship, constraints with problem space.
  - Models can be complet.
  - More flexible.
  - less Transparency

- **frame - based:** [cond'n 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.



→ Study Charactr of Prob
→ " Scope of Problem.
→ ROI analysis
→ Problem area identification

→ Problem is identify then decid the concept need for soln
→ language or Tool
→ Task of k-acquisition

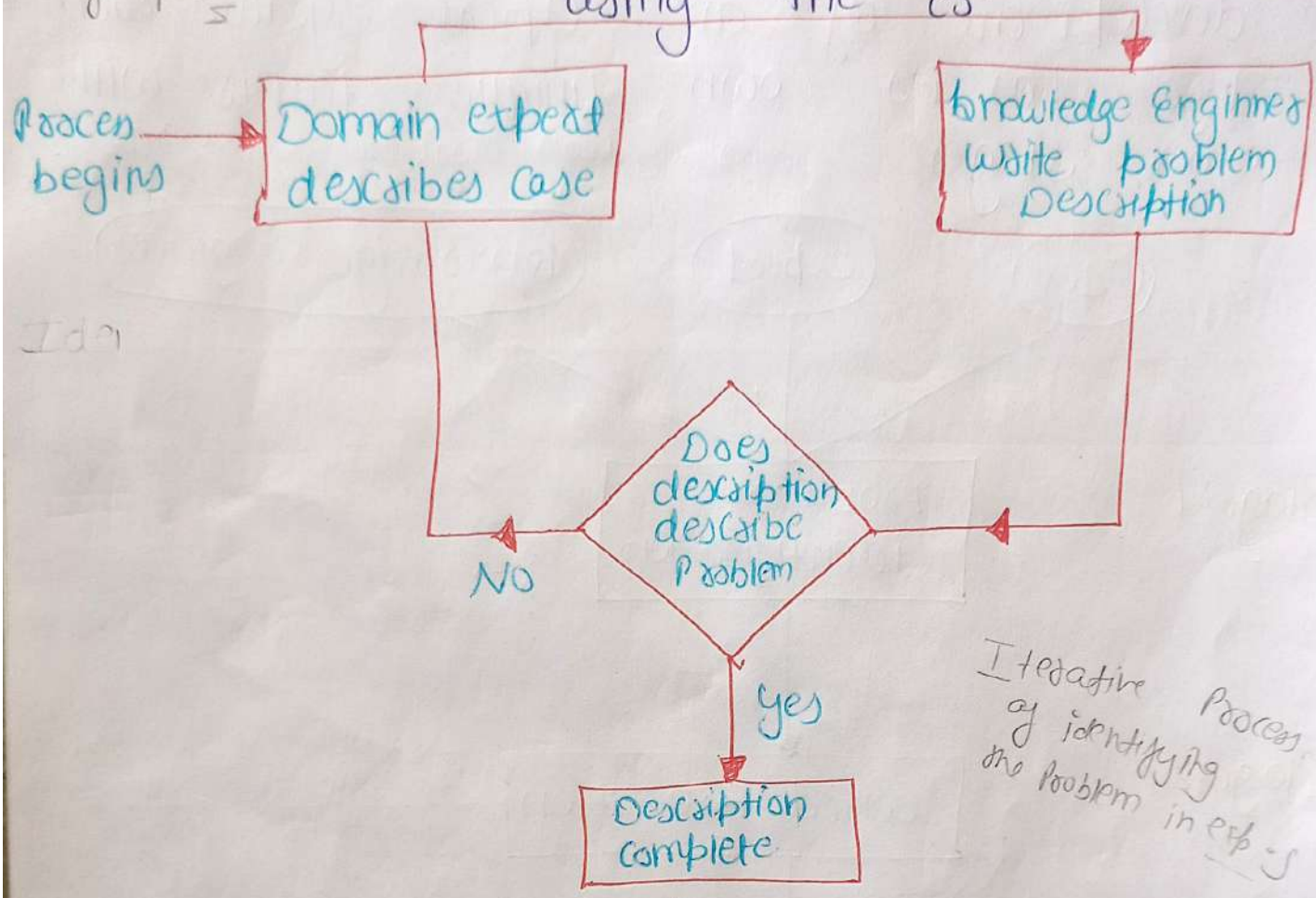
→ Additional interacti blw Multiple expert
→ Planning task

→ resource requirement
→ Maintanc of kb
→ Security

- Identify Problem Domain
- Design the System
- Develop Prototype
- Test
- Develop
- Maintain

- **Identification:** → figure out the spectic problem we want to solve using the ES.

Determining the Characters of problem

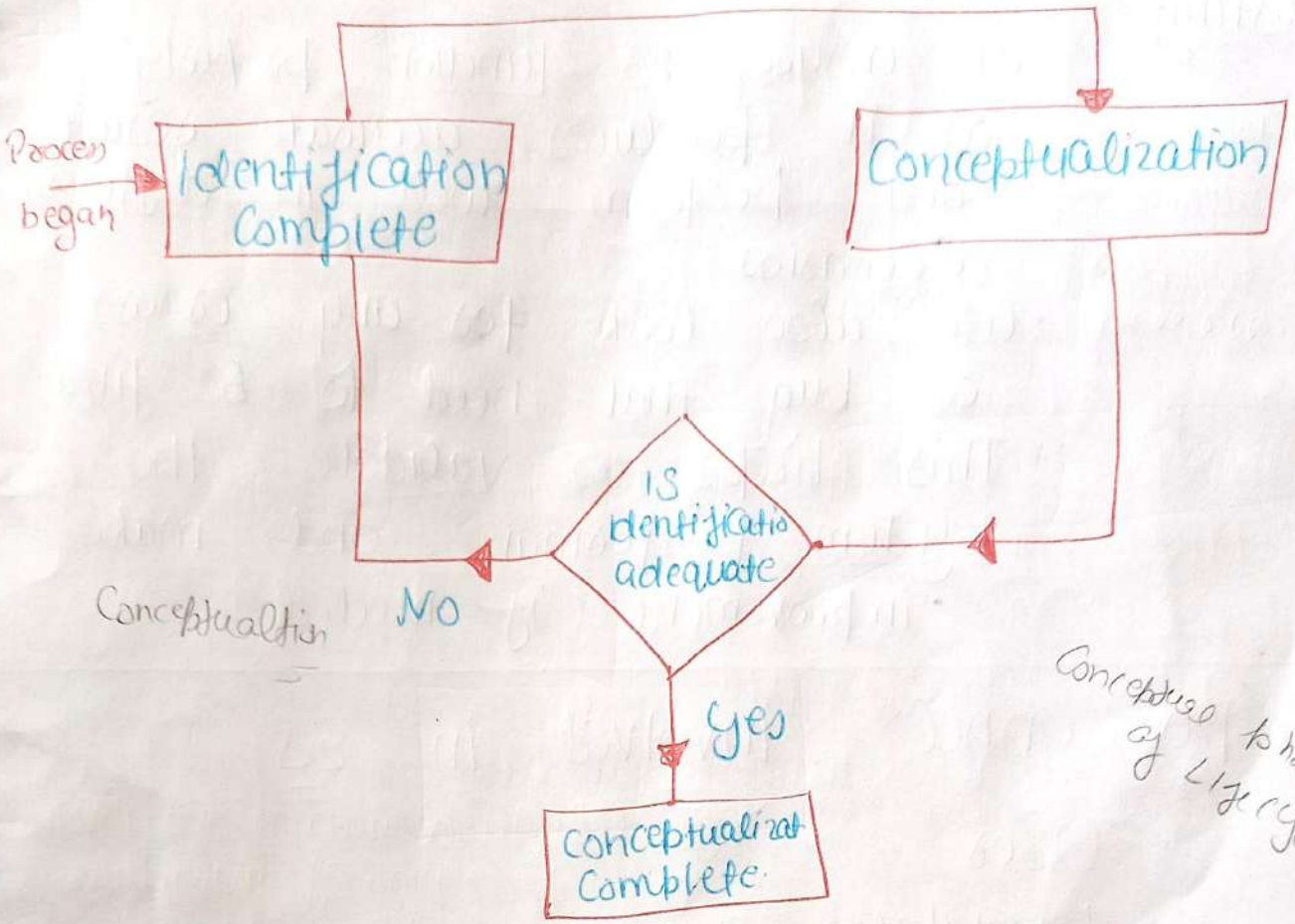


Iterative Process of identifying the problem in exp-S

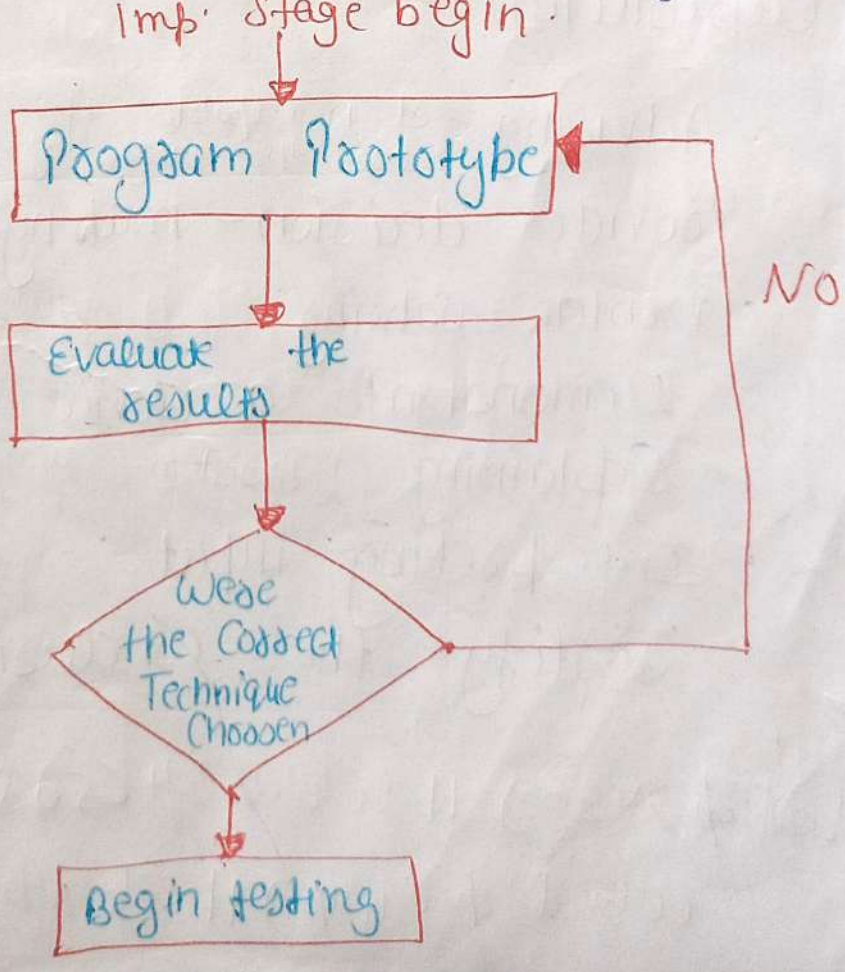
- **Conceptualization:** → Creat a plan and framework for our ES.
  - → what we want to achieve, set goals,
  - finding the concept to produce the solution of problem.

- **formalization:** → gather Information from experts in problem domain and organize into structur format to solve problem

Designing structs to organize the knowledge.



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



- Testing :→ It ensure ES function properly.
  - 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.

Validating the rules.

System implement correct or not rules

Personnel involved in ES

→ developing & maintaining ES involve a team of individual with skill & expertise.

- User
- Knowledge engineer ↳ problem find in my domain
- Domain expert → a person which have specific knowledge or skill in any area
- 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

→ AGE
→ EMYCIN
→ COOPS

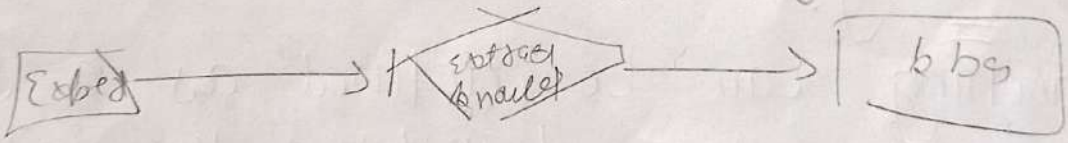
- Powerful editors for users interface.
- The right environment for expert to communicate
- Helps in rapid prototyping.

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 rules
* Participants in Development



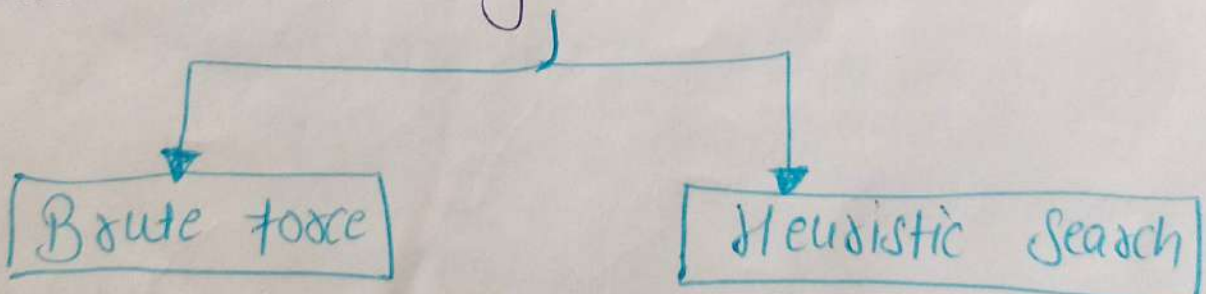
AI and Search Process

↙ Steps 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.

2) 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
- 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
  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 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.
- 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 Catalong Usage: relies on database, catalong.
- 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 explict 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

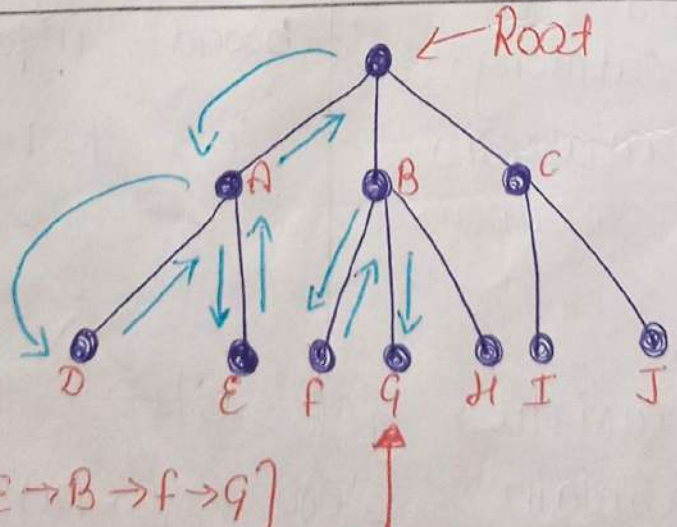
Step3: Remove the first node from START, Call them node a.

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 → F → G]

Goal.

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

Time Complexity

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

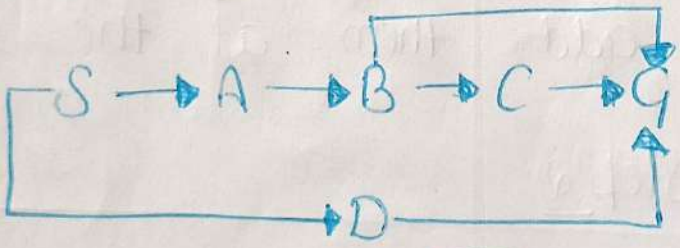
Space Complexity

- It maximum storage required at any point during the search.
- $O(d)$ → depth.

Drawback → Not find shortest path.

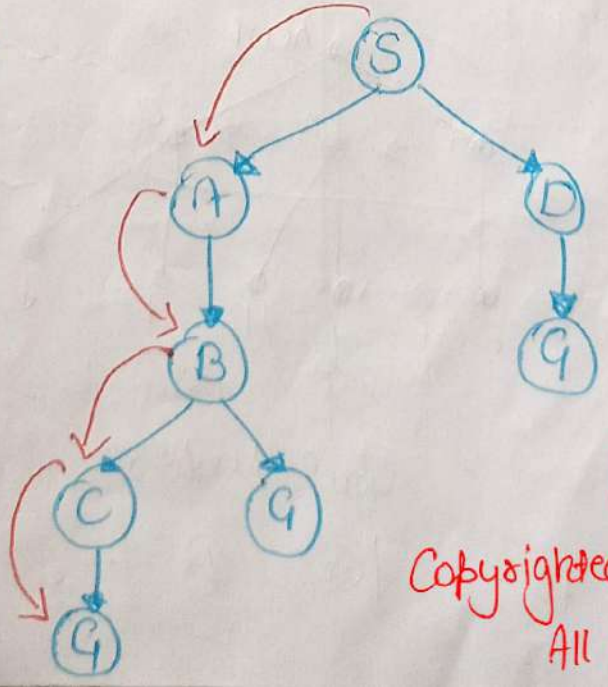
- Determination of depth until which the search has to process called cut-off depth.
  - → If cut-off depth is smaller, soln may not be found.
  - → If cut-off depth is large, time-complexity will be more.

Example:



[Deepest node first]

→ Traversal



[S → A → B → C → G]

Breadth first Search:

- Searching progresse is level by level.
- follow a direction.
- Start from first root and generate all posible children of node.
- implemented using a queue

Algorithm:

Step 1: Put the initel node on list START

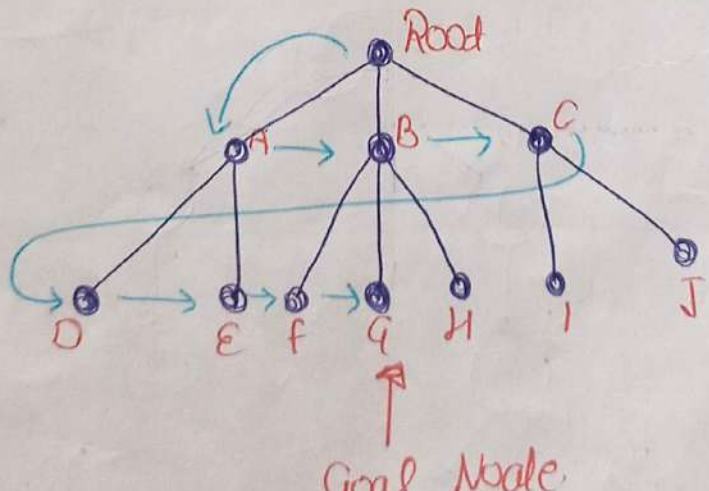
Step 2: If (START is empty) or (START = Goal) teminate with success.

Step 3: Remove the first node from START. Call them node a.

Step 4: If (a = Goal) teminate 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.

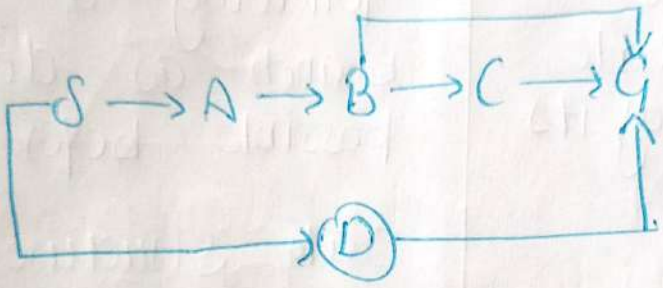


- Search tree for B-F-S.

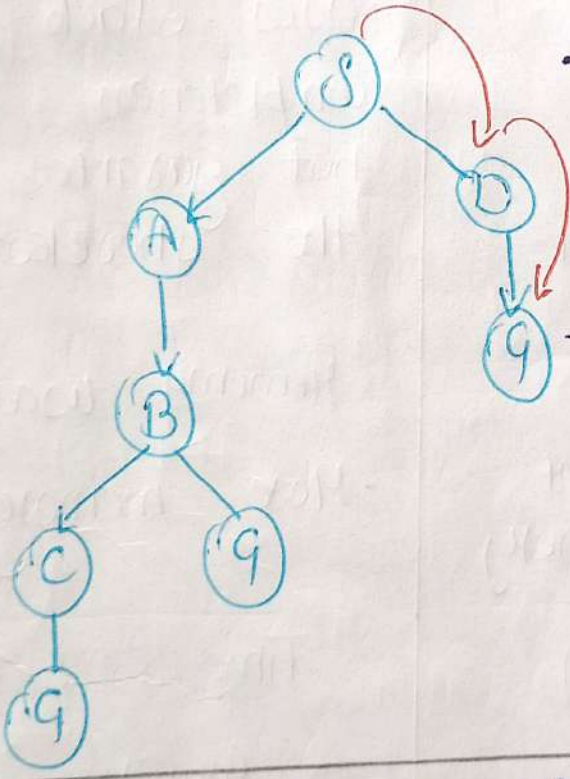
- Ilas to DFS, the two major factors.
  - → Time Complexity: $O(b^d)$
  - → Space Complexity: $O(b^d)$

⇒ Problem
- Amount of time needed to generate all node because of time complexity.

Ex:



[S to G]



→ level 0
→ level 1
→ level 2. [S → D → G]

↑ Shortest Path find.

- Completeness: A search algo is said to be complete if it is guarantee to return a solution if atleast any Sol^n for any random i/p.

Difference

BFS

- both are fundamental graph traversal algo
- Order of Exploration:
  - It explores nodes level by level. It start 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 Complexity
  higher

DFS

- same fundamental graph traversal algo
- Order of Exploration
  - It explores 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 Complexity
  lower.

- optimality : If a sol^n for an algo is guarantee to be best sol^n [lowest path] among all other sol^n. then such algo / sol^n is said to be optimal sol^n.

Hill Climbing

Gradient of Ascent / descent

→ 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

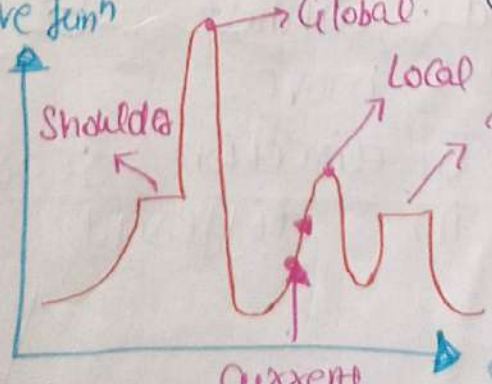
1) Greedy approach
2) No backtracking
3) Generate & Test

Types
- Simple
- Steepest-Ascent
- Stochastic

State-Space Diagram

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

- X axis: denote space state.
- Y axis: denote value of objective function



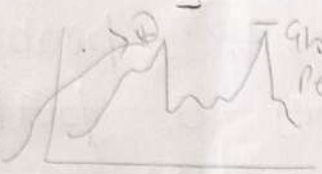
[Shoulder Plateau region which has uphill edge.

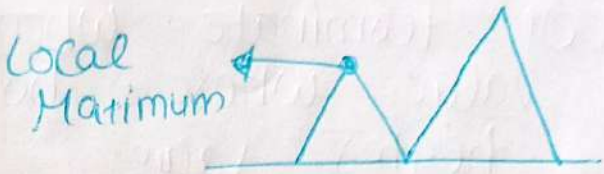
- Global: highest value of objective function
- Local: better than its neighbor states.
- Current: State in landscape diagram where agent present

Problem with hill Climbing

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

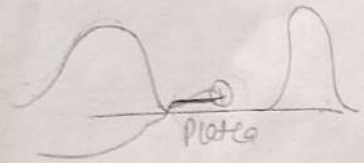
Sol^n: Backtracking technique. Sol^n of local Max in State space landscape.

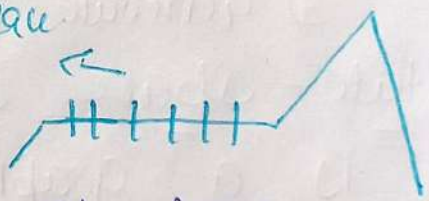




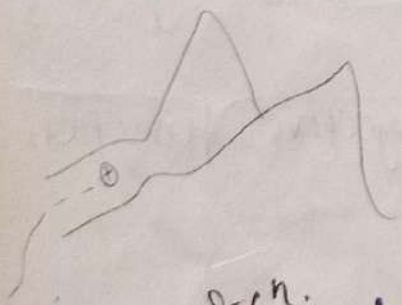
2) Plateau: flat area of search space in which all neighbour states of current states contain the same value, because algo not find any best direction to Move.

Sol^n: take big steps or little steps while searching.

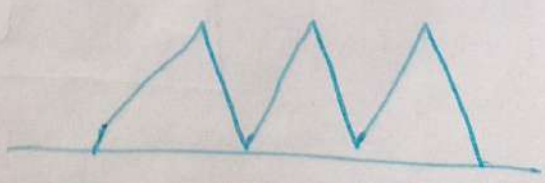


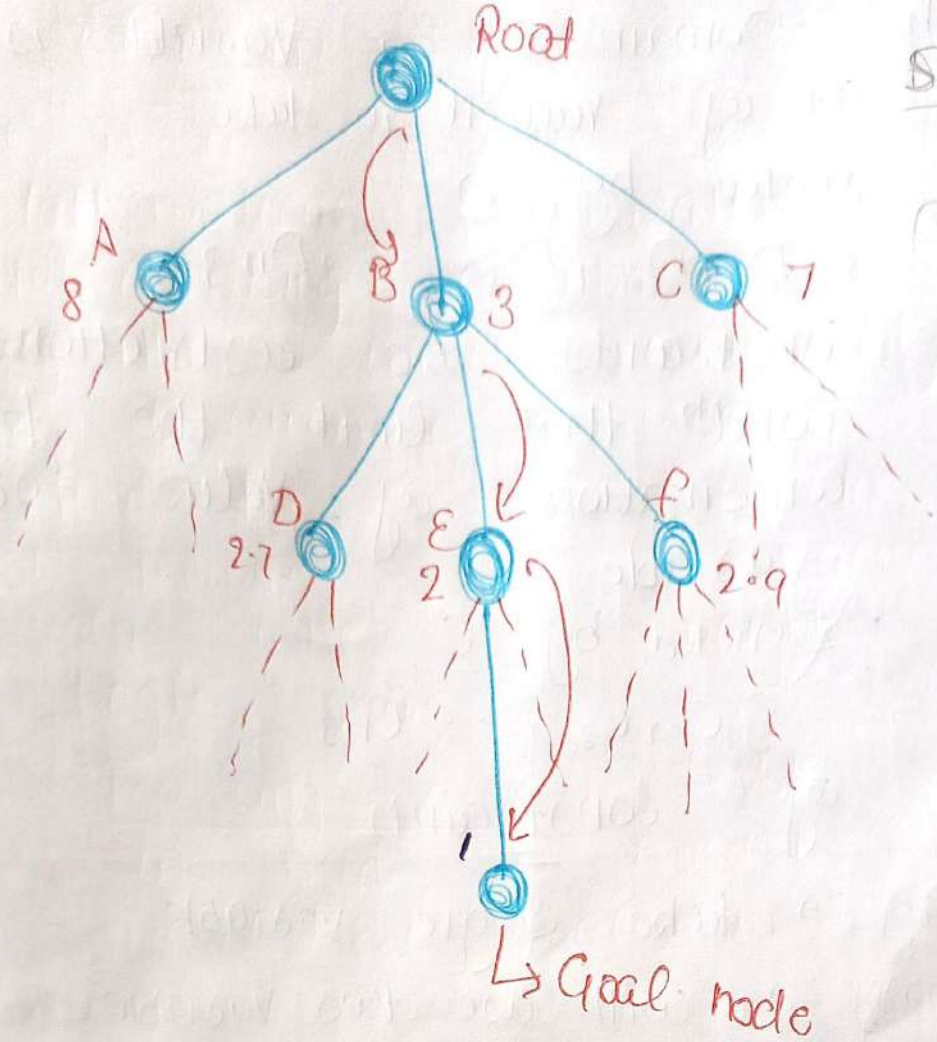


3) Ridges: Special form of local maximum. It has an area which is higher than its surrounding area, but itself has a slope, and cannot be reached in single move.



Sol^n: use bi-direction search or by moving in different direction.





S - B → E - G

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 constrain

→ Constraint Component

1) Variable. These are the entities whose value need to be determined.
   - Denoted by V
   - $\{V_1, V_2, V_3, \ldots, V_n\}$

- **Domain**: The Domain of a variable is the set of value it can take.
  - finite
  - Infinite
  - Continuous
  - Denoted by $\underline{D}$
  - $\{D_1, D_2, D_3 \cdots, D_n\}$
- **Constraint**: Constraints are restrictions or condⁿ that limit the possible combination of value for variable.
  - Denoted by $\underline{C}$
  - $\{C_1, C_2, \cdots C_n\}$

→ Type of Constraints

- Unary :→ take single variable.
- Binary :→ will use two variable.
- Global :→ will take more than variable and specify complet relations.

Representation [How to Constraints are satisfied]

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

$$C_i = (\text{Scope}, \text{relationship})$$

→ Scope: set of variable that participate in Constraint.

→ Relationship: define the value that variable can take.

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

→ V_1 V_2 [Scope]

Table value from Domain $(1,2)$ A B $(2,4)$ [Domain]

- $C_1 = \{(V_1, V_2), (V_1 \neq V_2)\}$ (Scope, Relationship)
- $C_1 = \{(V_1, V_2), (A, B)\}$

after applying some domain value:

$C_1 = (V_1 V_2, (1,2)(1,2)(2,4)$ → Constraint is satisfied.

eg: SUDOKU, Graph Coloring

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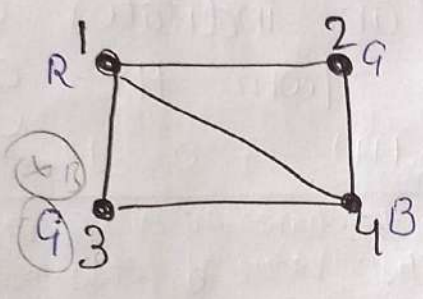
eg:



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

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

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

[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 = (G)			[G]	[B]

Backtracking

[Like DFS]

By default not empty

→ Not give blue due to constraint [value is empty then use Backtracking]

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

3 = G	R	G	G	B

- Time efficient.

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. $f(n) = h(n)$ (heuristic funct) [Goal node have an evaluating function value of zero.

$O(b^{d+1})$, $O(b^d)$

⇒ Algorithm

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.

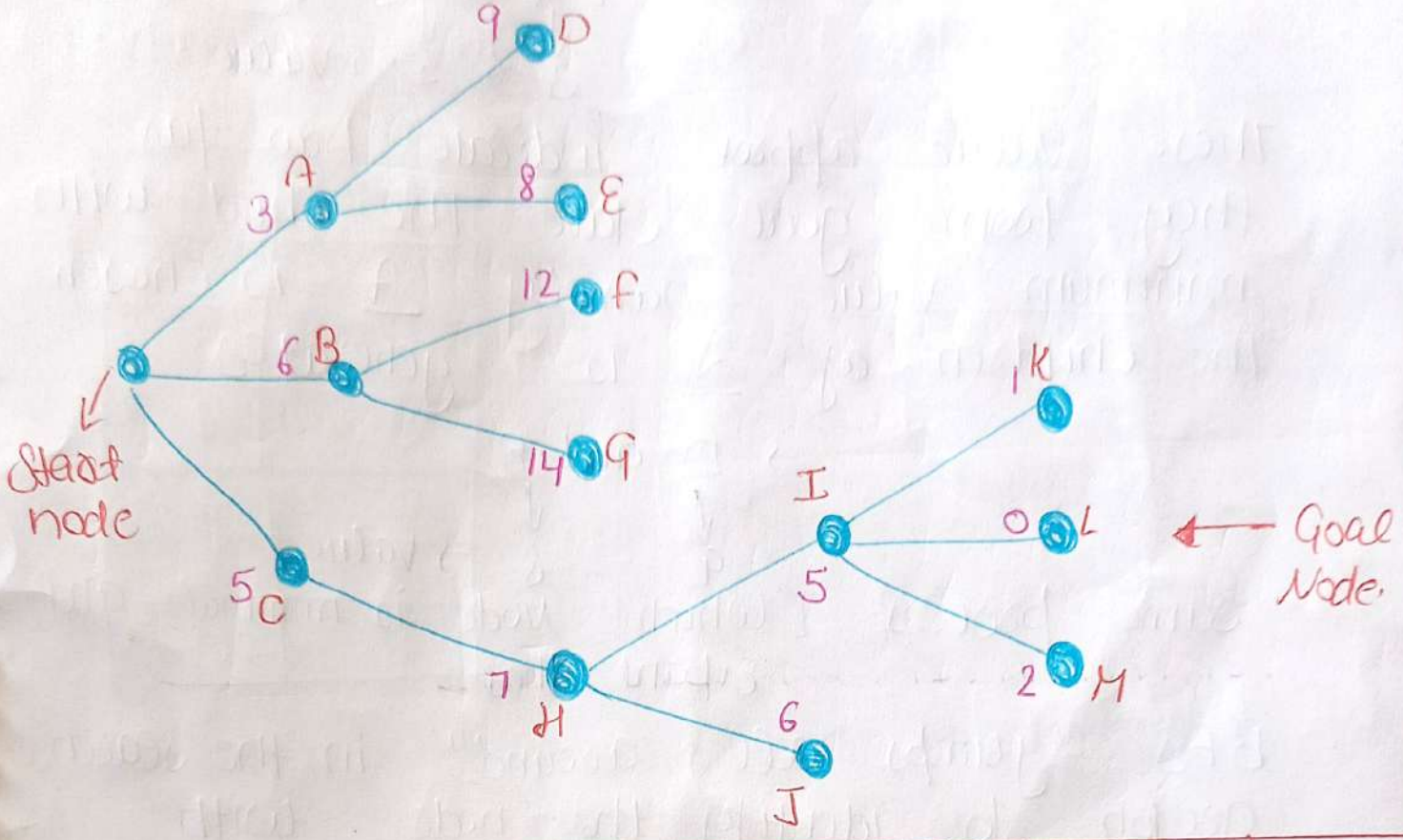
Step 5: Else if node a has successors, generate all of them. find out how far they are from goal state. Sort all the children generated so far [by the remaining distance from the goal. and add them to beginning of START]

Step 6: Name this list as START 1.

Step 7: Replace START with START 1

Step 8: Goto Step 2.

⇒ BfS is explained using a search graph



Steps	Node being Expand	Children	Available Node	Node Choosen
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]
  ↓ ↓ ↓
  3 6 5 → value.
  - These value approx. indicate how far they from goal state. The child with minimum value namely A is chosen.
  - The children of A is generates
    → D and E
    ↓ ↓
    9 8 → 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 evaulation function value and cost along path called fitness number.

fitness number ← $f(n) = g(n) + h(n)$

- $g(n)$: Estimated cost of cheapest soln
- $g(n)$: Cost of particular node from the start node
- $h(n)$: heuristic value which is given to a particular node. (estimated cost from the node n to goal)

⇒ 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: Else if node a has successors, generate all of them. Estimate the fitness numbers of the successors by totaling the evaluation function value and the cost function value. Sort the list by fitness numbers.

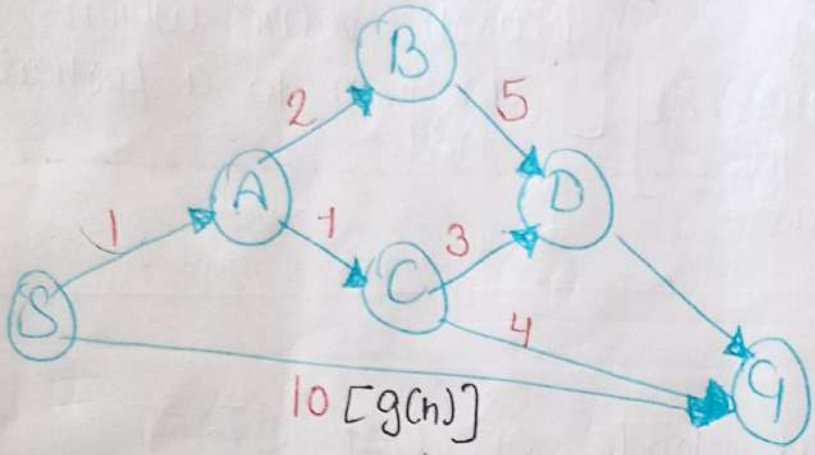
Step 6: Name the new list as START 1

Step 7: Replace START with START 1

Step 8: Go to Step 2.

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

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

Sol^{n}: # Iteration: 1

	g(n)	h(n)	
$S \to A$	1	3	= 4
$S \to G$	10	0	= 10 hold

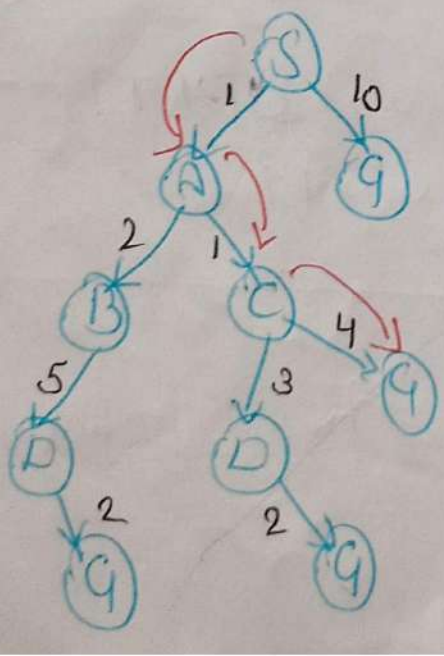
Iteration: 2

$S \to A \to B$	3	4	= 7
$S \to A \to C$	2	2	= 4

Iteration 3:

$S \to A \to C \to D$	= 11
$S \to A \to C \to G$	= 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".

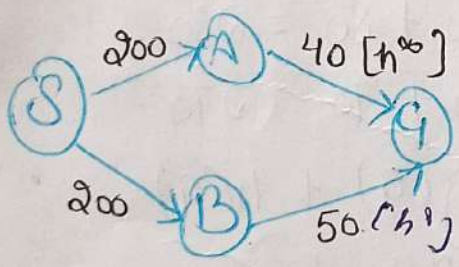
1) $h(n) \leq h^*(n)$ [Underestimation]
2) $h(n) \geq h^*(n)$ [Overestimation.

Underestimation: If the estimated value is less than actual value. [optimal]

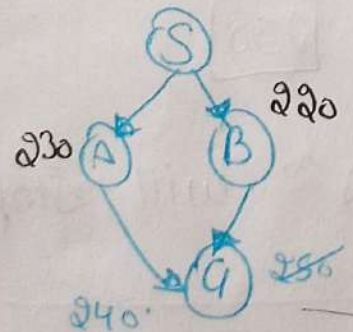
"$h(n) \leq h^*(n)$

↓ estimated ↓ actual value

#



- $g(A) = 200$
  $g(B) = 200$
- Let $h(A) = 30$
  $h(B) = 20$
- $f(A) = g(A) + h(A)$
  $= 200 + 30 = \boxed{230}$
- $f(B) = 200 + 20 = \boxed{220}$



← Choose f(B)

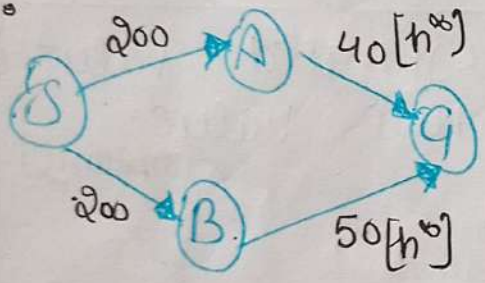
- $f(G) = g(G) + h(G)$
  $= 250 + 0$
  $= \boxed{250}$

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

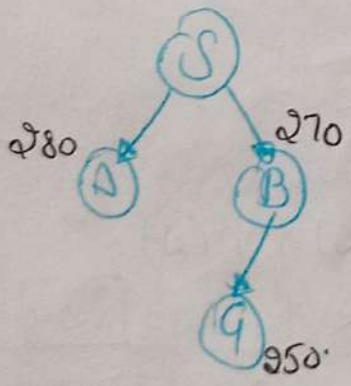
$$f(G) = g(G) + h(G)$$
$$= 240 + 0$$
$$\boxed{f(G) = 240} \rightarrow \text{optimal answer.}$$

Overestimation: ↳ of estimated value is more than actual value.

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



- $g(A) = 200$
  $g(B) = 200$
- Let $h(A) = 80$, $h[B] = 70$ $\Big\} > h^*$
- $f(A) = 200 + 80 = 280$
  $f(B) = 200 + 70 = 270$
  $f(G) = g(G) + h(G)$
  $= 250 + 0$
  $= \boxed{250}$



- from here, A^* will stop.

Advantages

- optimal and complete
- Use in shortest path algo
- Solve complex problem

Disadvantage

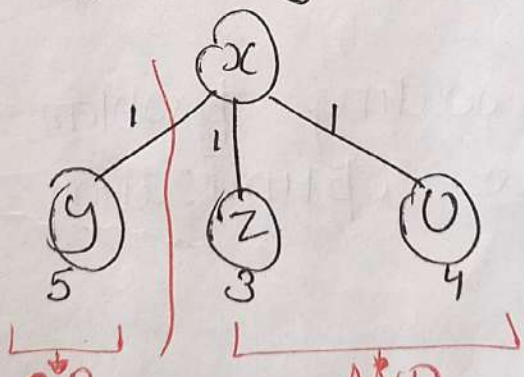
- Used extra memory as compared to BFS require
- Some complexity issues.

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:



- $f(n) = 1+5 = 6$

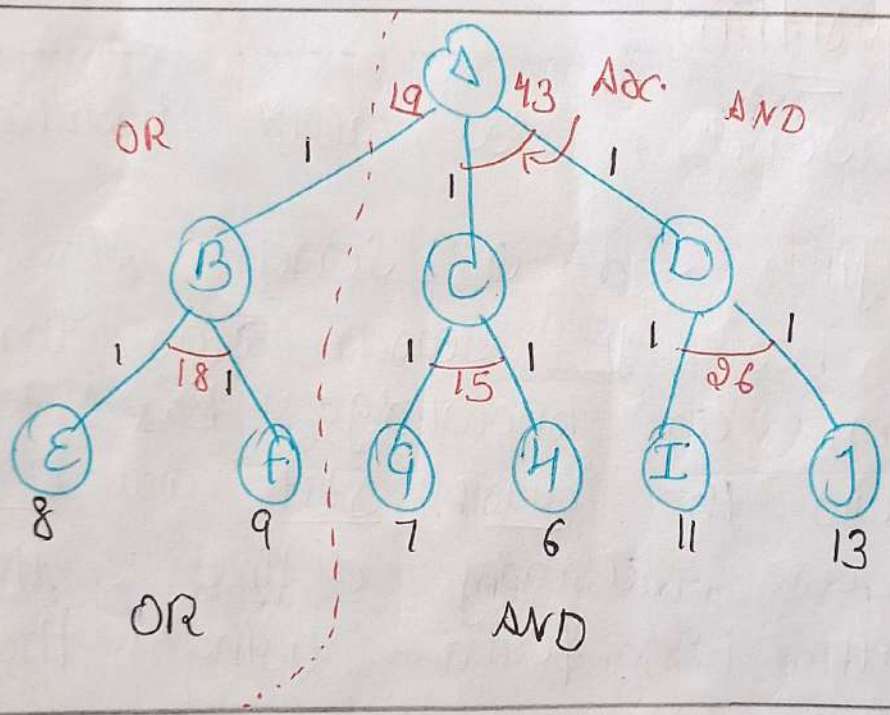
$f(n) = 1+3+1+4 = 9$

- Works on problem decomposition.
- It use the concept of AND-OR graphs decompose the complet problem into a set of sub-problem to reach out the goal state.

AND: Set of task 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.

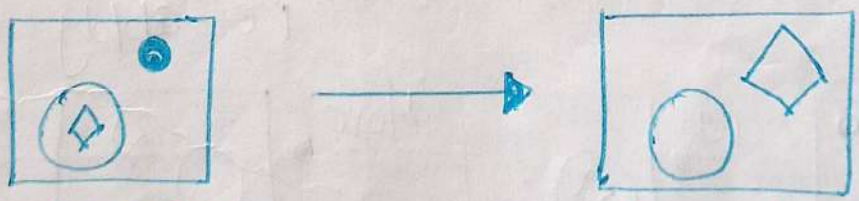
Mean - End - Analysis

- Mean - End - analysis is problem - solving techniques used in Artifical intelligence for limiting search in AI Programs.
- It is a Mixture of Backward & forward search technique.
- 1961, Allen Newell.
- The MEA analysis process blw the Cussent State & goal State.

How its works

- first, evaluate the difference blw initial State and final State
- Select the vasious opesatoss which can be applied for each difference.
- Apply the opesatos at each difference, which reduce the difference b/w the Cussent State and goal State.

Ex:



Initial State

Goal State.

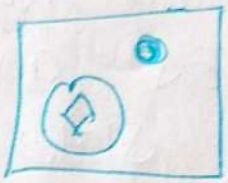
- In this problem, we need to get the goal State by finding differ b/w initial State & goal State and applying opesatoss.

Sol: first generate a new state and apply operators

↓

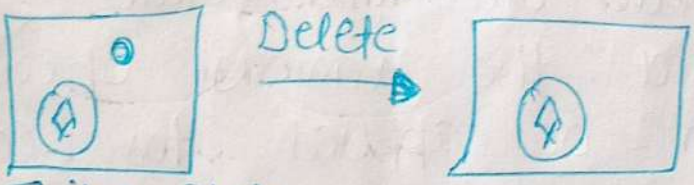
- Move
- Delete
- Expand

1) Evaluating inital State:

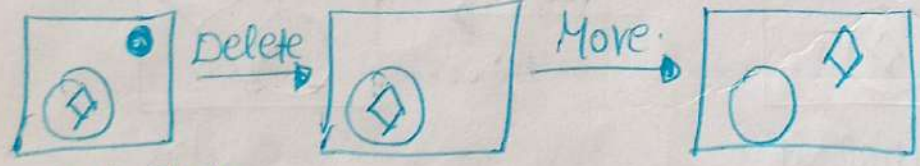


initial State.

2) Apply Operator [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 move operator

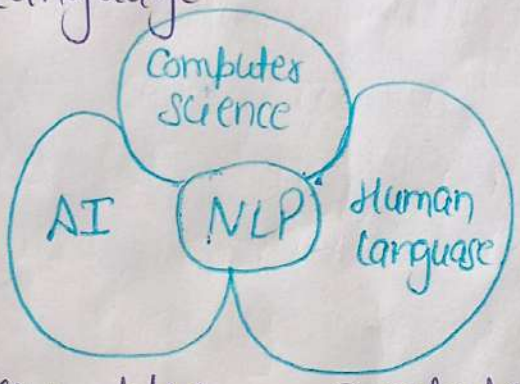


4) Apply Expand operator: after compare, one difference which is size of square, so apply Expand and finally, generate goal state

Natural language Processing

How Human Communicate with each other.

- NLP is a part of Computer science, Human language, and Artifical intelligence.
- It is the technology that is used by machine to understand, manipute 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 Understand
- Data processing & analysis
- Speech recognition
- Sentiment analysis
- Information retrieval

Advantages

- help users to ask question about any subject and get a direct response within seconds.
- less 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

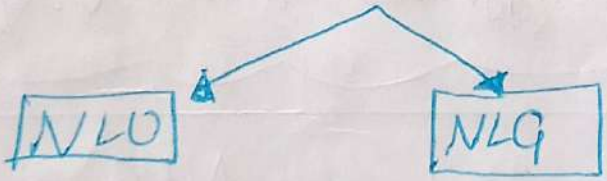
Disadvantage

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

Lack of understanding
Complexity
Ambiguity
Privacy issues

Components of NLP

- There 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.

- Cathbot

NLU is difficult than NLG

#	NLU	NLG
	• It 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 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.

3) Sentiment analysis: also known as opinion mining. define combination of NLP and identify the mood of context

4) Machine Translation: used to translate text or speech from one natural language to another natural language
   - English → hindi
   - eg: Google Translator

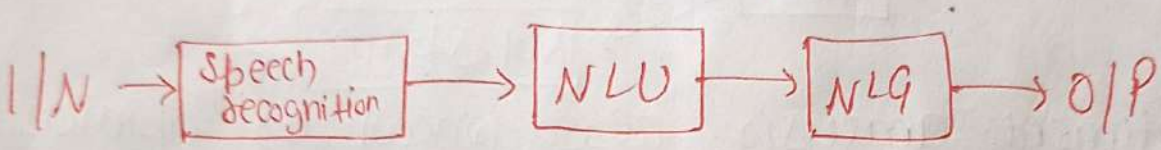
5) Spelling Correction: Microsoft Corporation provides word processor software like MS-Word.

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 computers 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

- Techniques.
  - Tokenization
  - Part of Speech Tagging
  - Machine learning
- NLTk, TTS, STT

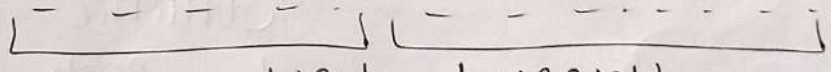
#NLP Pipeline

- 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 steps 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:



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

eg: Celebrates, Celebrated and Celebrating all are origination with single root word "Celebrate".

→ Problem: Not have any meaning [root word.

4) Lemmatization :- Similar to Stamming. used to group different infected form of word:
→ which has a meaning of root word.

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

6) Dependency Passing :- It is used to find that how all the world 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) Leg Lexical analysis: involves identifying and analyzing the structure of words.
- It divides the whole text into paragraphs, sentences.

2) Syntactic analysis: used to check grammar, word arrangements and shows the relationship among the words.
eg: Agra goes to Poonam
→ Not sense, rejected by SA.

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

4) Disdourse 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 word and phrases can have Multiple meaning based on context

- lexical : exists in presence of two or more possible meaning of sentence within a single world.

  eg: MANYa is looking for Match

- Syntactic : 2 or more possible meaning within sensetece.
- Referential : When you are referring to something using the pronoun.

→ Sol^{n} : Implement algo and Contextual Model that considers Context and consider the surrounding words and meaning

→ Lack of Contextual awareness : To understand any word is crucial for accurate info.

Sol^{n}: Develop Models

- AI researches use various techniques where models are trained on amount of text data to recognize patterns and understand language structure.
- These Models learn how word are used in different contexts, allowing them to make more accurate.

→ Subjective language → with different expressions.

→ Sol^{n}: By using Models. can better respond and understand.

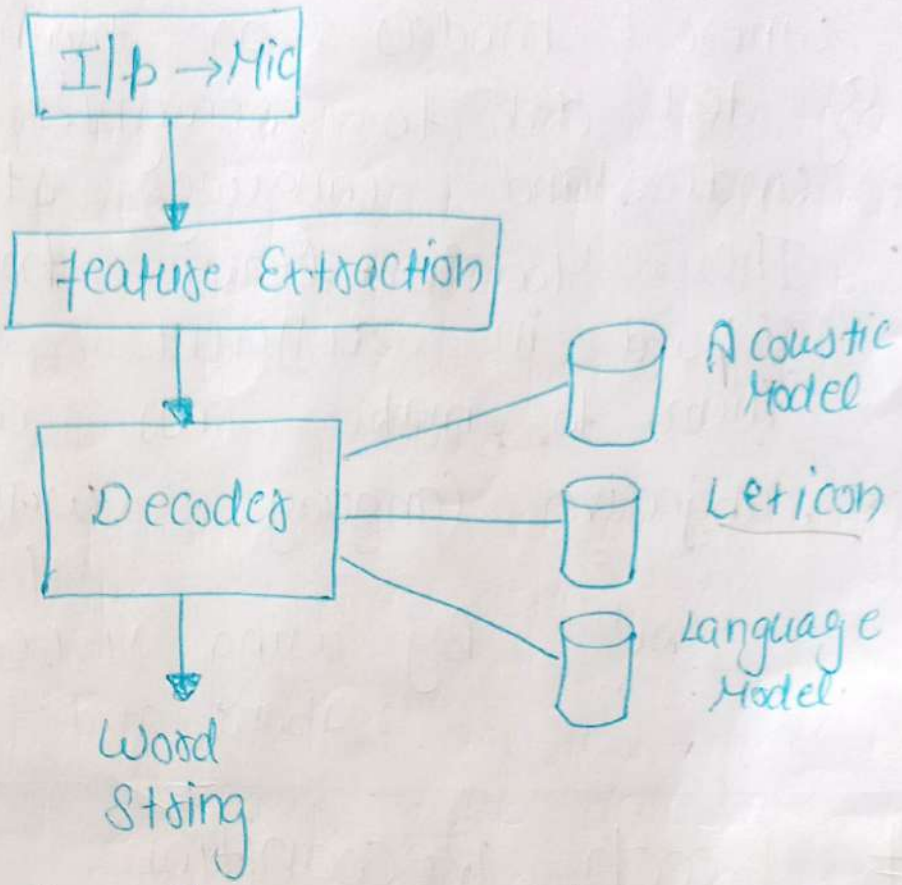
Speech Recognition

- 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 ← physical device without input
- Multitasking
- Improved user interface.
- Accessibility. → use technology

=> 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 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 the likelihood of word sequence in given language.

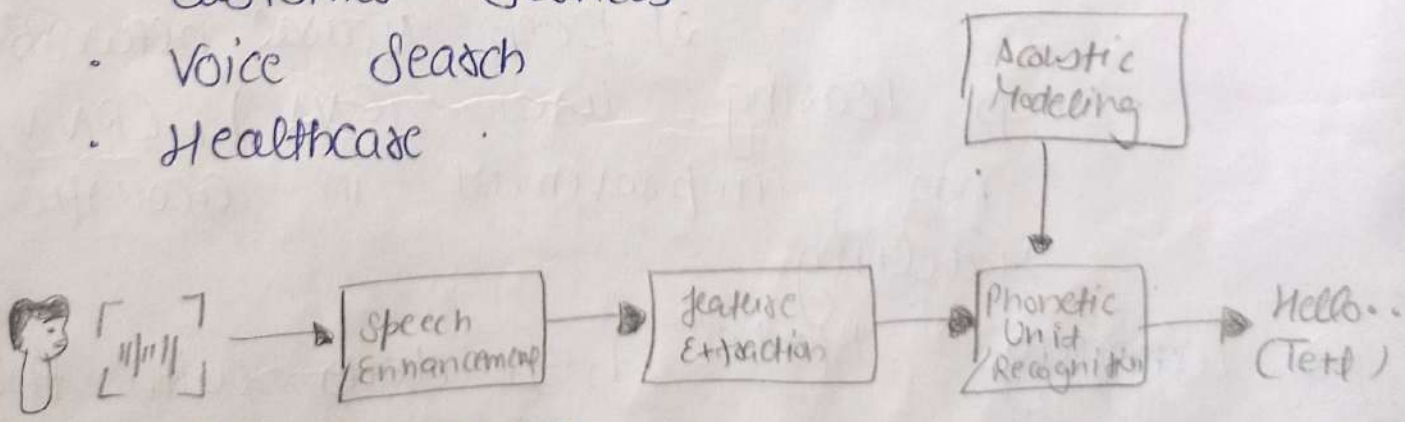
↓
Sound are matched with word sequence.

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 above.

Approaches of Speech recognition

→ Acoustic Model

- The Acoustic Model is a Statistical model that represent the relationship b/w the acoustic feature of speech signal and the corresponding phenomes (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 phenomes 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 :

It deals with the linguistic aspects of spoken words.

- It responsible for predicting the likelihood of a sequence of words occuring in particular order. It helps in improving the accuracy of the transcation 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
· Improved Accuracy
Di 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 give to it using programming.

Ex: · Drug Compounding robot
· Automotive Industry robots.

→ Types of robots

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

Parts of robots

Sensors

- 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.

Control system

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

End effector

Controlling a robot

Control System
Sensor
Actuator

Process
control algo
Remote control

- AI robots are controlled by AI programs and use different technologies of AI. such as 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 ; Actuators, Control System, Sensors, 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 Link btw known as End effectors. The device which connect the arms of robots.
- **Locomotive Device**: which are responsible to move the robot in any direction in dependen
- **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 [need the structure of body]
- Brain
- Sensors [gather info]
- Actuators [Robot move and act with help]
- Program [work on instructions]
- Behaviour / autonomy

Application of Robotics

→ In defence sector
→ 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 computer to operate on.

Robots

- 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 robots or machine.
- Combination of Electrical engineering, Mechanical engineering and computer science.

⇒ Three principle of Robotics

given by Issac's Asimov

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

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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 artifical intelligence (the ability to think & learn).

Features

- Learning Capability
- Perception
- Decision making
- Autonomy

Ex: Self-Driving Car
· Vacuum 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 smart to understand where they are and where they should go

Type:
1) Autonomous
2) Non-autonomous

feature:
· Mobility
· Navigation
· Sensors.

Ex: Delivery robots.

Classification

· Based on environment in which they work.
→ aerial, Land or Home robot
· Based on device they use to work
→ Wheeled, Humanoid