Unit 1

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(1) **AI** :- It is a branch of CS by which we can create intelligent machines which can behave like human, think like human & able to make decisions.

Goals → Replicate human intelligence
→ Solve knowledge intensive task
→ Build machines that require human intelligence.

Advs → High Accuracy
→ High speed
→ useful for risky areas
→ Digital assistant
→ useful for public utility

Disadvs → High cost
→ can't think out of box
→ No feeling, No emotion
→ Use dependency on machines.
→ no creativity

(2) **Approaches to AI**

→ **Reactive Machine** → Most basic form of AI
→ donot store memory/past exp. or future actions
→ focus on current situation
→ Eg. IBM's chess playing super comp.

→ **Limited Memory** → can store memory for short time
→ Eg. self driving car.

→ **Theory of Mind** → where bots will understand & react to human emotions, thoughts.
→ Not developed, under research.

→ **Self Awareness** :→ future of AI, super intelligent machines
→ will have own consciousness, sentiment & self awareness.
→ smarter than human.
→ hypothetical, does not exist.

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(3) Applica's of AI

- Astronomy : universe related probs.
- Healthcare : better & faster diagnosis.
- Gaming
- Finance : fraud detection
- Data Security : prevent cyber attack.
- Social Media : identify trends
- Travel & Transport : suggesting travel options.
- Automotives : Self driving car.
- Robotics.
- Agriculture :- crop monitoring
- Education
- E-commerce.

(4) Problem Solving in AI

- Goal formulation :- It organises the steps required to formulate 1 goal out of multiple goals as well as actions to achieve that goal.
- Prob. formulation :- It decides which actions should be taken to achieve the formulated goal.

→ Components of Prob-formulation

- Initial State : Starting state of agent towards its goal
- Actions : Possible actions available to the agent.
- Transition Model :- It describes what each act does.
- Goal Test :- Determines if the given state is a goal state
- Path Cost :- Cost to follow a given path.

An optimal sol^n has the lowest path cost among all the sol^ns.

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Natural Language Processing :- Branch of AI that enables comps. to comprehend, generate & manipulate human language like English etc.

Components → Natural Language Understanding (NLU)
Mapping given i/p in natural lang. into useful representations.

Natural Lang. Generation (NLG)
producing meaningful phrases & sentences in the form of natural lang. from some internal representation

Steps in NLP

- Lexical Analysis : dividing whole chunk of text into para, sentences & words.
- Syntactic Analysis :- analyzing grammar & order of words such that it shows the relationship among the words.
- Semantic Analysis :- Text is checked for meaningfulness
- Discourse Integration :- Brings out the meaning of immediately succeeding sentence.
- Programmatic Analysis :- Deriving those aspects of lang. which require real world knowledge

Appns :- chatbot
- Improve Search
- Social Media Analytics.
- Search Engine optimization
- Market insights.

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(6) Automated Reasoning : area of CS that is concerned with applying reasoning in the form of logic to computing systems.
→ deductive reasoning in maths & logic.
Appⁿs : → Proving theorems
→ checking proofs of
→ Design circuits.

~~Visual P~~
(7) Visual Perception :- ability of comps: to see & interpret images.
⇒ It includes :-
1) acquiring images using image sensors,
2) processing the image digitally ;
3) extracting meaningful info.
4) representing info. as models.
5) converting the model representation into numerical or symbolic info. interpretable by a comps.

(8) Knowledge in AI :- It means to have some info. saved in the memory from the prior experience of sth like abty, skills, objects or facts.
Role of Knowledge in AI :- creating AI
→ demonstrating intelligent behaviour in AI agents.

Types of Knowledge → Declarative (know about sth)
→ Procedural (how to do sth)
→ Meta (knowledge about other types of knowledge)
→ Heuristic (knowledge of some expert in a field)
& rule of thumb, based on previous exp / awareness of approaches, good to work but not guaranteed
→ Structural (basic knowledge to prob. solving)

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(9) Heuristic Algo-

- based on intution, guess, explora^n.
- yield suboptimal result
- can't be proven mathematically
- don't yield same ans. everytime

Sol^n guaranteed Algo.

- based on finite set.
- yield optimal result.
- can be proven
- give same ans.

(10) Soft Computing :- Refers to a grp. of computational techniques that are based on AI & natural selec^n.

- It provides cost effective sol^n to the complex real life probs. for which hard computing sol^n doesn't exist.

Appⁿs → Gaming Products like Poker, Checker
↳ Microwave, washing machine, Fridge,
↳ Heater, AC.
↳ Robotics.
↳ & Image Processing, Data Compression

Techniques of Soft Computing

↳ Fuzzy logic (FL)
↳ Neural Nw (ANN)
↳ Genetic Algos (GA)

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AI (Unit-2)

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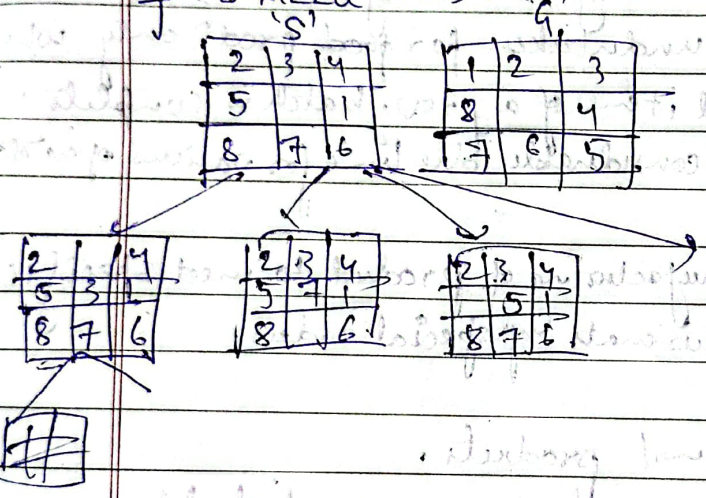
Representing probs in state space :

→ A state space is defined as a set of all possible states of a prob.
→ A state space search representation allows for the formal def^n of a prob. that makes move from the initial to goal state.
→ (Precise) def^n of prob. & agent can properly (analyze) each move.

S: { S, A, Action(s), Result(s, a), Cost(s, a) }

- S: Start, Goal
- A: all possible actions (up, down, right, left)
- Action(s): Action taken in state 's'
- Result(s, a): Resultant state after taking and 'a' on state 's'
- Cost(s, a): cost of taking action 'a' in state 's'.

Eg. 8 Puzzle prob.



Uninformed Searching	Informed Searching
1) Search without info.	→ Search with info.
2) No knowledge	→ Use knowledge to find steps to sol^n (requisite knowledge).
3) Time Consuming	→ Quick sol^n (may have to compromise with optimality).
4) More complex (Time, Space)	→ Less complex
5) DFS, BFS etc.	→ A*, Heuristic DFS, Greedy etc. (estimated value).

NOTE: Heuristic knowledge/Heuristic f^n (h(n)) is used when we have all prob. with exponential growth.

Eg.. Travelling Salesman prob.
We use the nearest neighbour concept as heuristic know

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Production System :- Helps in structuring AI progs in a way that facilitates describing & performing the search process.

PS consist of:
- Set of Rules : if-then rules
- Knowledge base : stores info. corr. to particular task.
- Control Strategy : Order in which the rules need to be compared to the db so that conflict can be resolved in min. time.
- Rule Applier :- Applies the rules over control strategy.

Steps to solve the prob :-
- First reduce prob. so that it can be shown in a precise statement.
- Prob can be solved by searching a path through space. [Start → Goal]
- Solving process can be modelled.

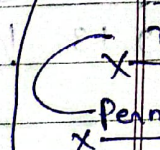
Advs. → Structuring AI Prob.] → excellent tool.
→ Highly modular] → rules - add, remove, change
→ Rules are expressed in natural form] → easy to understand

Characteristics :-

→ Monotonic PS :- App^n of a rule never prevents later app^n of another rule] Rules are independent.

→ Non-Monotonic PS :- is one in which this is not true.

→ Partially Commutative PS :- If app^n of a particular sequence of rules transforms state X to Y, then allowable permutations of those rules also transforms state X to Y.



→ Commutative : Both monotonic & partially commutative.

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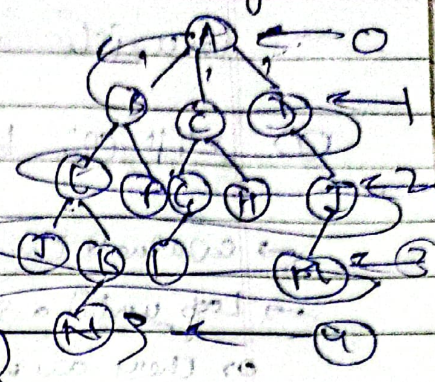
We only have prepeal knowledge
and we don't have domain level knowledge.

BFS



Uninformed Search Tech.
FIFO (Queue)
Shallowest (Nearest) Node.
Complete (surely finds an element)
optimal (Shortest Path)
Time Complexity : O(V+E) + $O(b^d)$
b → branch factor (no. of children of each node)
d → depth

DFS

Uninformed Search Tech.
Stack (LIFO).
Deepest Node
Incomplete (may get trapped in a loop or ∞ search space)
Non-optimal
Time Complexity : $O(b^d)$

Heuristics in AI

→ It is a tech. designed to solve a prob. quickly.
→ It provides good solⁿ but doesn't guarantee to provide optimal solⁿ.
How to calc. Heuristic fⁿ
↳ Euclidean distance
↳ Manhattan distance
↳ No. of misplaced tiles, etc.

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Heuristic Search Tech.

① Hill Climbing Algo (Local search along greedy approach, no backtrack)

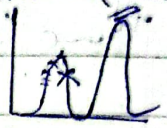
→ Evaluate the initial state

→ Loop until a soln is found or there are no operators left.:

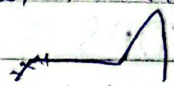
-) Select & apply a new operator.
-) Evaluate the new state:
  - ⊛ if goal then quit.
  - ⊛ if better than current state then it is new current state

Probs. in Hill Climbing

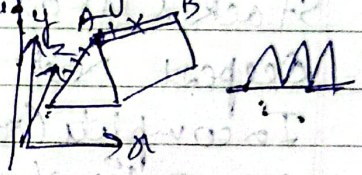
1) Local Maxima Stop

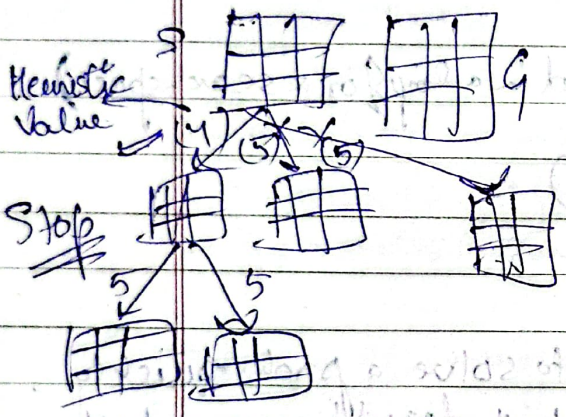


2) Plateau / Flat Maxima Stop



3) Ridge (no direc" change)





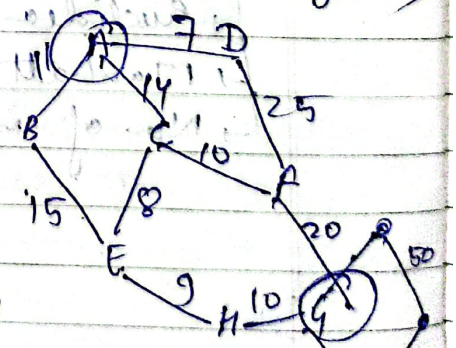
② Best First Search (Informed, Heuristic)

~~get~~ good soln, but no guarantee of optimal.

→ Let 'OPEN' be a priority queue containing initial state.

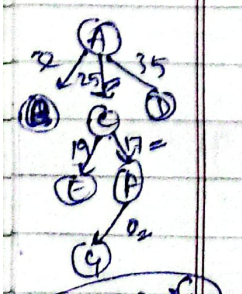
→ Loop:

-) if OPEN is empty, return failure
-) Node ← Remove-First (open):
  - ⊛ if Node is goal, then return the path from initial to ~~goal~~ Node
  - ⊛ else generate all successors of Node & put the newly generated node into OPEN acc'ing to their f' values



Estimated Straight Line Dist.

A → G	= 40
B → G	= 32
C → G	= 25
D → G	= 35
E → G	= 19
F → G	= 17
H → G	= 10
G → G	= 0



Example

Acc'ing to heuristic, A → C → F → G = 14 + 10 + 20 = 44

w/o heuristic, A → C → E → H → G = 41

Admissible (guarantees ~~optimal~~ sol^n)

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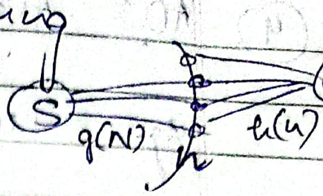
(3) A* Algo → Informed searching

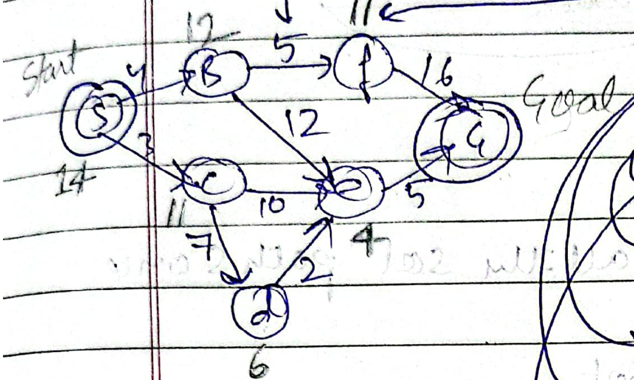
$TC = SC = O(b^d)$

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



g(N): Actual cost from start node to 'n'

h(N): Estimation cost from n to goal node.



S→B = 4+12 = 16

S→C = 3+11 = 14

SC→d = 3+7+6 = 16

SC→e = 3+10+4 = 17

~~Scd~~

~~SB→f = 5+4+11 = 20~~

~~SB→e = 4+12+4 = 20~~

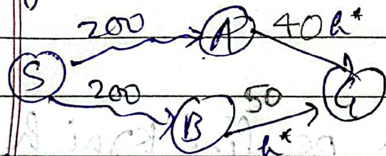
~~Scd→e = 3+7+2+4 = 16~~

Scde→G = 3+7+2+5 = (17)

$h(n) \leq h^*(n)$ ⇒ underestimation (h(n): estimated, $h^*(n)$: Actual)

$h(n) \geq h^*(n)$ ⇒ overestimation

NOTE: We will always get the optimal ans in the case of underestimation.



g(A) = 200

g(B) = 200

Case I: Overestimation	Case II: Underestimation
h(A) = 80, h(B) = 70] > h*	h(A) = 30, h(B) = 20] < h*

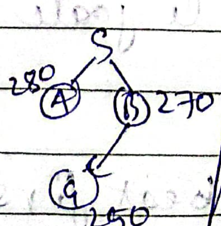
Case I:

f(A) = 200+80 = 280

f(B) = 200+70 = 270

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

= 250 + 0 = 250



Case II:

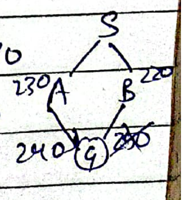
f(A) = 200+30 = 230

f(B) = 200+20 = 220

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

= 250+0 = 250

f(G) = 240+0 = 240



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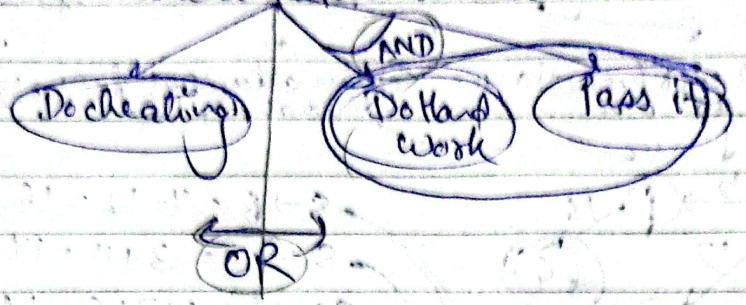
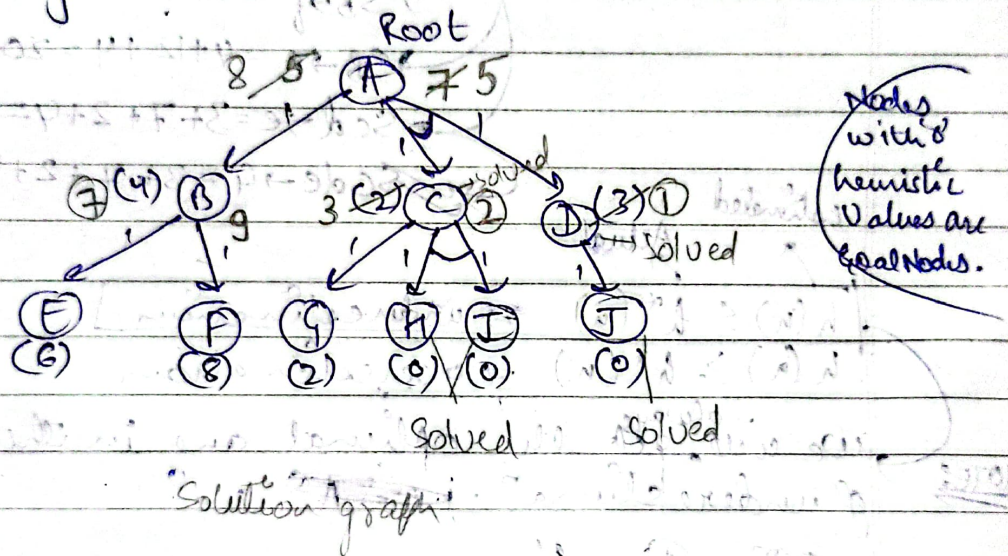
→ Admissible (always gives soln)

(4) AO* Algo (AND/OR) → Prob decomposition (breakdown into smaller pieces)

eg. Want to Pass in Exam



AO* doesnot explore all the soln paths once it gets a soln.



How AO* works ?

Aapko pehele ek level pe find krni h new heuristic value, fir dusre level pe find krni h new heuristic value, fir is value ke basis pe hum upar ke levels ki heuristic values update krte hn or root tak le jaate hn.

A* v/s AO*

Both work over best first search.

Both are informed search in which heuristic values are given.

AO* doesnot guarantee optimal soln.

A* always gives optimal soln when we work on underestimation.

→ pts. for winning or loosing.
Max → user
Min → comp.

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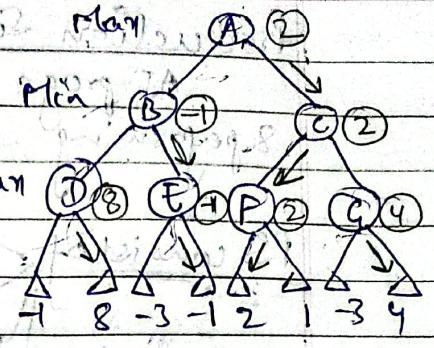
Game Playing Algo

(1) Minimax Algo.

→ Backtracking Algo.
→ Best move strategy used.
→ Max will try to maximize its utility (Best move).
→ Min will try to minimize utility (worst move).



Game tree.

branch factor

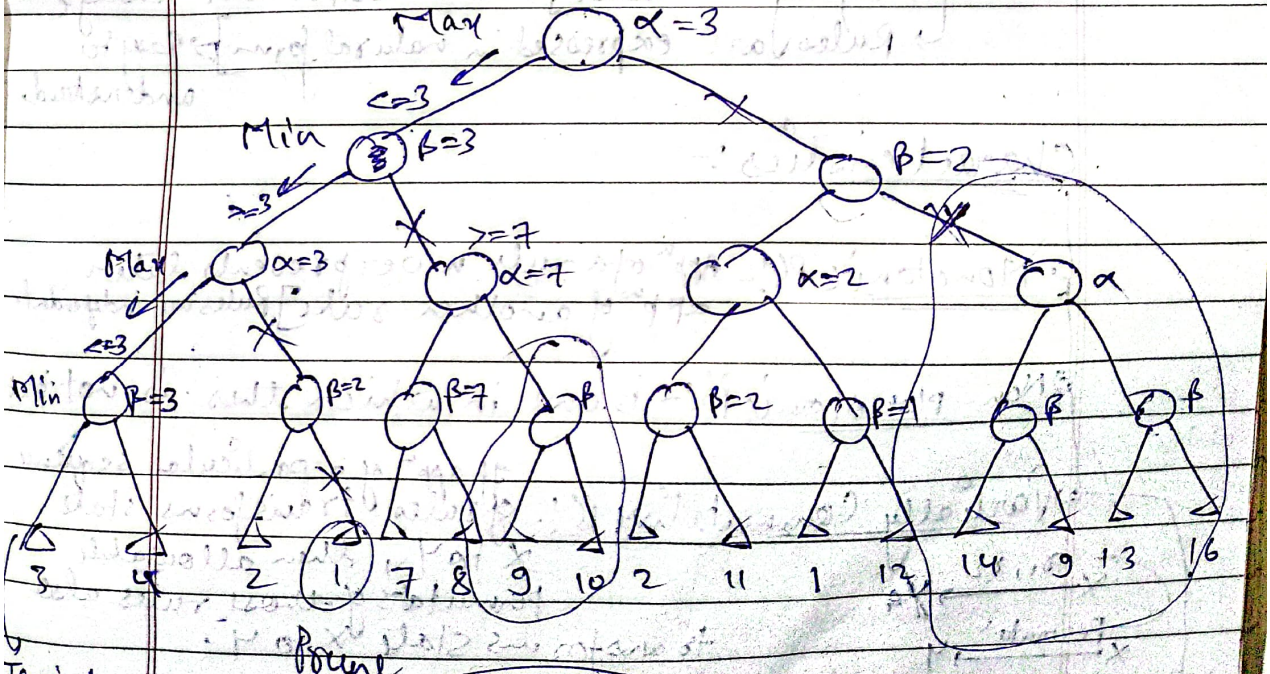
$TC = O(b^d)$ ← depth/ply

∴ we don't use Minimax in all games bcoz for games like Chess, its space tree might become very ~~long~~ large.

(2) Alpha-Beta Pruning (α-β)

→ for min node
→ for max node

→ Modification over minimax.
→ Cut off search by exploring less no. of nodes.
→ Once we find a best path, then we prune (cut-off) rest of the paths, we won't explore them.



$TC = O(b^{d/2})$

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