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ARTIFICIAL INTELLIGENCE II

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DIGITAL LEARNING CONTENT

UNIT-2

Heuristic Search Techniques

Heuristic Search Techniques in AI

Heuristics operates on the search space of a problem **to find the best or closest-to-optimal solution via the use of systematic algorithms**.

- In contrast to a brute-force approach, which checks all possible solutions exhaustively, a heuristic search method uses heuristic information to define a route that seems more plausible than the rest.
- Heuristics, in this case, refer to a set of criteria or rules of thumb that offer an estimate of a firm's profitability.
- Utilizing heuristic guiding, the algorithms determine the balance between exploration and exploitation, and thus they can successfully tackle demanding issues. Therefore, they enable an efficient solution finding process.

Components of Heuristic Search

State Space: This implies that the **totality of all possible states or settings**, which is considered to be the solution for the given problem.

Initial State: The **instance in the search tree of the highest level with no null values,** serving as the initial state of the problem at hand.

Goal Test: The exploration phase ensures **whether the present state is a terminal or consenting state in which the problem is solved.**

Successor Function: This create a situation **where individual states supplant the current state which represent the possible moves** or solutions in the problem space.

Heuristic Function: The function of a heuristic is **to estimate the value or distance from a given state to the target state.** It helps to focus the process on regions or states that has prospect of achieving the goal.

Why do we need heuristics?

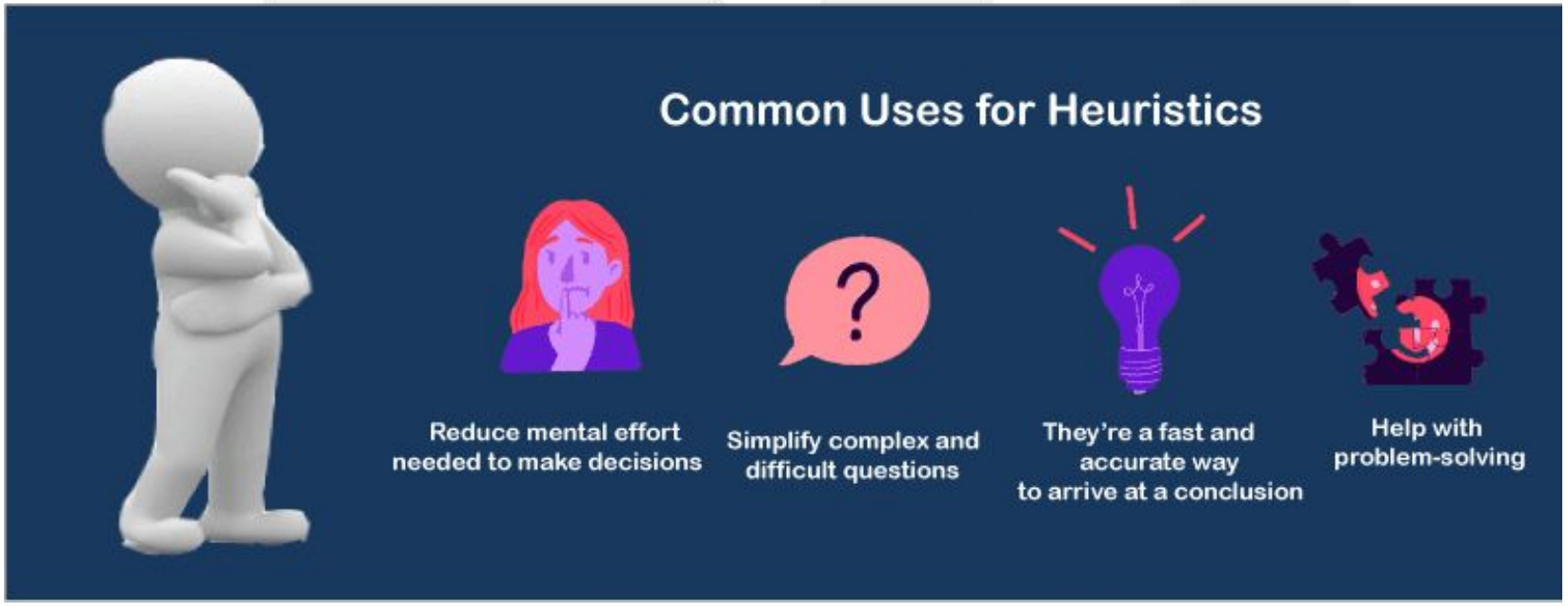
Speed and Efficiency: Heuristic searches prioritize the most promising paths, making them faster than traditional search algorithms.

Real-World Applications: In tasks like search engines, autonomous systems, and route planning, heuristic search techniques improve performance by narrowing down search options.

Scalability: Heuristic searches are particularly valuable when dealing with large and complex datasets, where traditional search methods would be too computationally expensive.

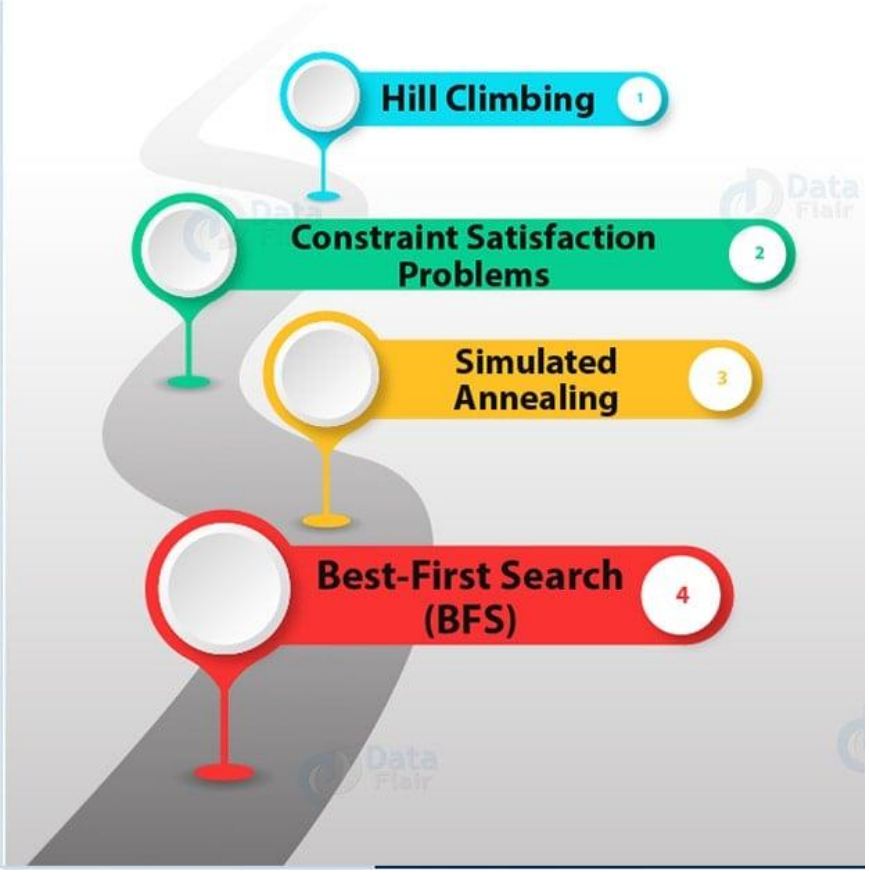
Real-World Example

Autonomous vehicles use heuristic search techniques to plan their routes in real time, taking into account factors like traffic, road conditions, and distance. This ensures that the vehicle reaches its destination efficiently while avoiding obstacles or delays.



Types of Heuristic Search Techniques

- A* Search Algorithm
- Greedy Best-First Search
- Hill Climbing
- Simulated Annealing
- Beam Search
- Problem reduction
- Constraint satisfaction
- Means-Ends analysis



A* Search Algorithm

- A* Search Algorithm is perhaps the most **well-known heuristic search algorithm**.
- It uses a **best-first search and finds the least-cost path** from a given initial node to a target node. It has a heuristic function,
- often denoted **as f(n)=g(n)+h(n),**

where **g(n)** is the cost from the **start node to n,**
and **h(n)** is a heuristic that **estimates the cost of the cheapest path from n to the goal**.

- A* is widely used in pathfinding and graph traversal.

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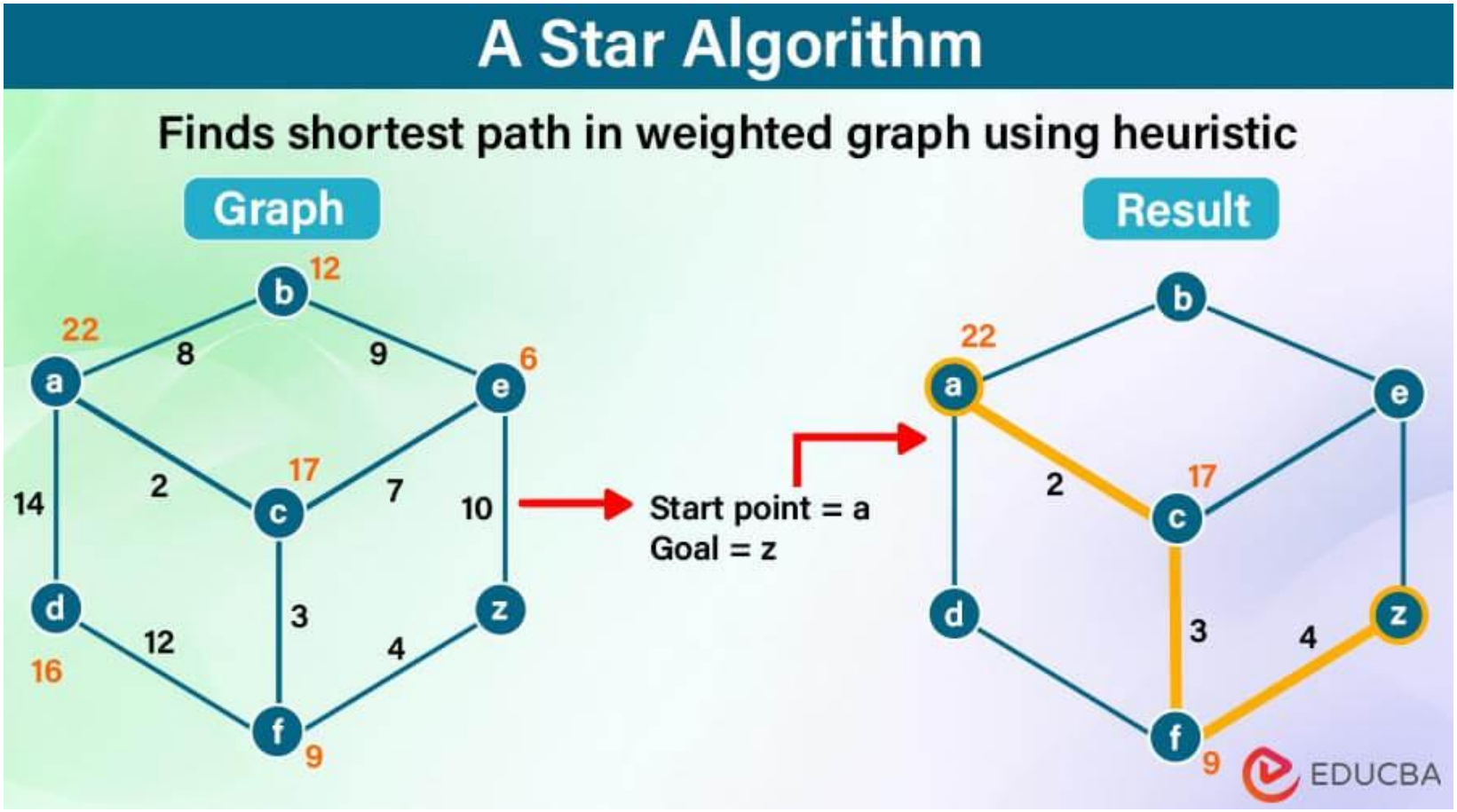
A* Search Algorithm



Greedy Best-First Search

Greedy best-first search expands the node that is closest to the goal, as estimated by a heuristic function. Unlike A*, which takes into account the cost of the path from the start node to the current node, the greedy best-first search only prioritizes the estimated cost from the current node to the goal. This makes it faster but less optimal than A*.

GREEDY BEST FIRST SEARCH

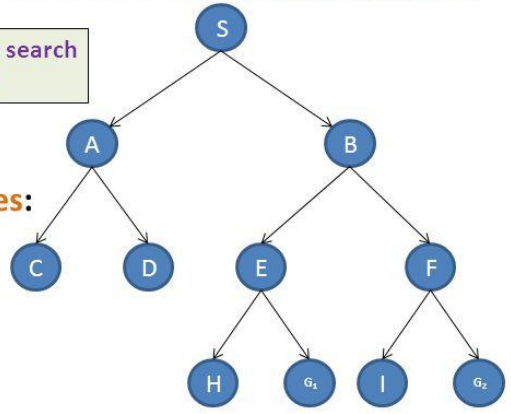
- **Greedy best-first search is a best first search but uses heuristic estimate h(n) rather than cost function.**
- **Both follow the same process but Greedy uses heuristic function whereas best first uses cost function.**
- **EXAMPLE:**

NOTE: similar to Best first search but uses heuristic values.

S: Initial state, G_1,G_2: goal.

Table shows the heuristic estimates:

node	h(n)	node	h(n)	node	h(n)
A	11	D	8	H	7
B	5	E	4	I	3
C	9	F	2		



Greedy Best-First Search

The Algorithm

1. Initialize a tree with the root node being the **start node in the open list.**
2. If **the open list is empty, return a failure, otherwise, add the current node to the closed list.**
3. **Remove the node with the lowest h(x)** value from the open list for exploration.
4. If a **child node is the target, return a success**. Otherwise, if the node has not been in either the open or closed list, add it to the open list for exploration.

Hill Climbing

1.Evaluate the initial state. If it is a goal state, return success.

2.Make the initial state the current state.

3.Loop until a solution is found or no operators can be applied:

3. Select a new state that has not yet been applied to the current state.
4. Evaluate the new state.
5. If the new state is the goal, return success.
6. If the new state improves upon the current state, make it the current state and continue.
7. If it doesn't improve, continue searching neighboring states.

4.Exit the function if no better state is found.

Hill Climbing

Hill climbing is a heuristic search used for **mathematical optimization problems.** It is a variant of the gradient ascent method.

Starting from a **random point**, the algorithm takes steps in the direction of increasing elevation or value to find the peak of the mountain or the optimal solution to the problem.

However, it may settle for a local maximum and not reach the global maximum.

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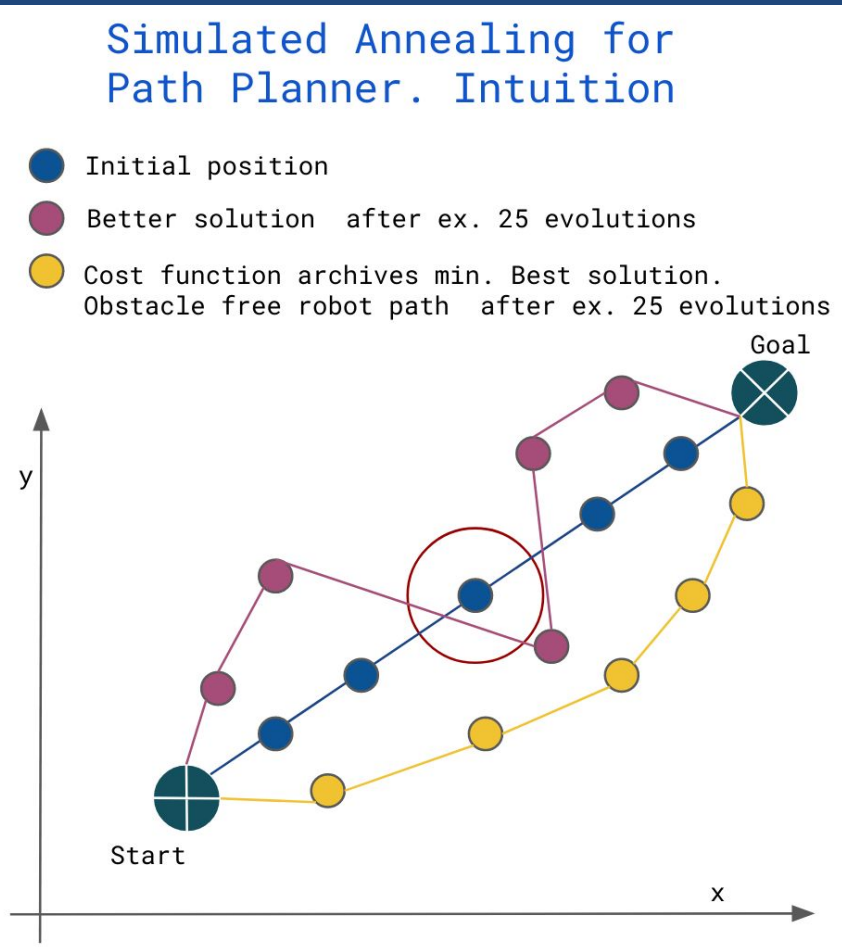
Simulated Annealing

Inspired by the process of annealing in metallurgy, simulated annealing is a probabilistic technique for approximating the global optimum of a given function. It allows the algorithm to jump out of any local optimums in search of the global optimum by probabilistically deciding whether to accept or reject a higher-cost solution during the early phases of the search.

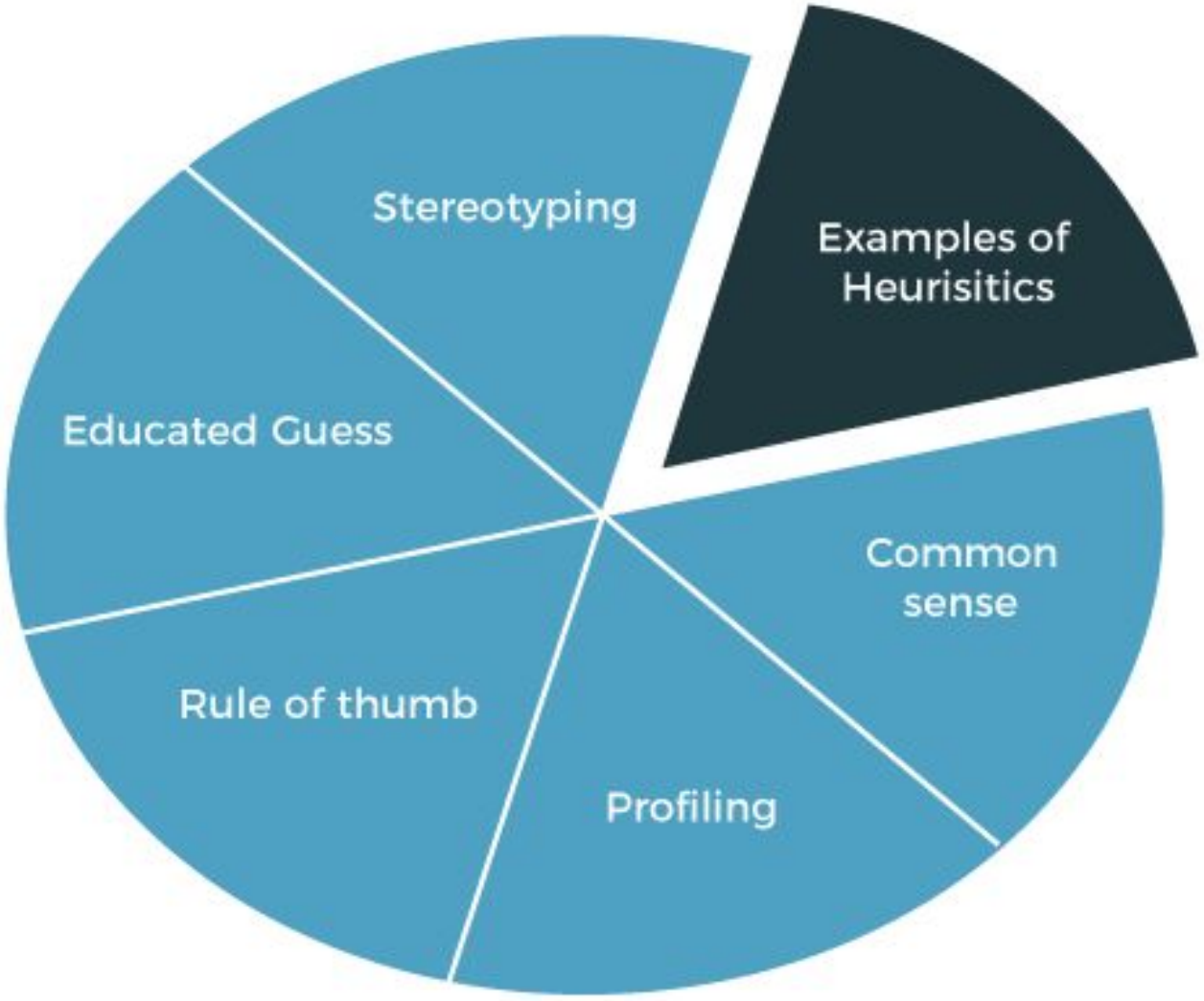


Beam Search

Beam search is a heuristic search algorithm that explores a graph by expanding the most promising nodes in a limited set or "beam". The beam width, which limits the number of nodes stored in memory, plays a crucial role in the performance and accuracy of the search.

Applications of Heuristic Search

- **Pathfinding:** Discovery, of the shortest distance that can be found from the start point to the destination at the point of coordinates or graph.
- **Optimization:** Solving the problem of the optimal distribution of resources, planning or posting to achieve maximum results.
- **Game Playing:** The agency of AI with some board games, e.g., chess or Go, is on giving guidance and making strategy-based decisions to the agents.
- **Robotics:** Scheduling robots` location and movement to guide carefully expeditions and perform given tasks with high efficiency.
- **Natural Language Processing:** Language processing tasks involving search algorithms, such as parsing or semantic analysis, should be outlined. That means.


Stereotyping
Examples of Heurisitics
Educated Guess
Common sense
Rule of thumb
Profiling

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Examples of heuristics in everyday life

Common sense: It is a heuristic that is used to solve a problem based on the observation of an individual.

Rule of thumb: In heuristics, we also use a term rule of thumb. This heuristic allows an individual to make an approximation without doing an exhaustive search.

Working backward: It lets an individual solve a problem by assuming that the problem is already being solved by them and working backward in their minds to see how much a solution has been reached.

Availability heuristic: It allows a person to judge a situation based on the examples of similar situations that come to mind.

Familiarity heuristic: It allows a person to approach a problem on the fact that an individual is familiar with the same situation, so one should act similarly as he/she acted in the same situation before.

Educated guess: It allows a person to reach a conclusion without doing an exhaustive search. Using it, a person considers what they have observed in the past and applies that history to the situation where there is not any definite answer has decided yet.

Advantages of Heuristic Search Techniques

Efficiency: As they are capable of aggressively digesting large areas for the more promising lines, they can allot more time and resources to investigate the area.

Optimality: If the methods that an algorithm uses are admissible, A* guarantees of an optimal result.

Versatility: Heuristic search methods encompass a spectrum of problems that are applied to various domains of problems.

Limitations of Heuristic Search Techniques

Heuristic Quality: The power of heuristic search strongly depends on the quality of function the heuristic horizon. If the heuristics are constructed thoughtlessly, then their level of performance may be low or inefficient.

Space Complexity: The main requirement for some heuristic search algorithms could be a huge memory size in comparison with the others, especially in cases where the search space considerably increases.

Domain-Specificity: It is often the case that devising efficient heuristics depends on the specifics of the domain, a challenging obstruction to development of generic approaches.