Artificial Intelligence: Uniform Cost Search

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TE/AI-DS/26

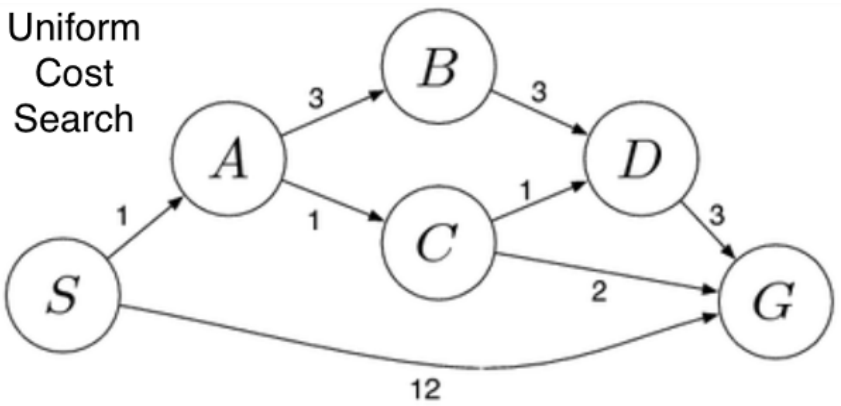
Introduction:

Uniform Cost Search (UCS) is a graph traversal and search algorithm used in the field of artificial intelligence and computer science. UCS is an informed search algorithm that explores a graph by gradually expanding nodes starting from the initial node and moving towards the goal node while considering the cost associated with each edge or step.

Understanding Uniform Cost Search:

This algorithm is mainly used when the step costs are not the same, but we need the optimal solution to the goal state. In such cases, we use Uniform Cost Search to find the goal and the path, including the cumulative cost to expand each node from the root node to the goal node. It does not go depth or breadth. It searches for the next node with the lowest cost, and in the case of the same path cost, let's consider lexicographical order in our case

Example:



->In the above figure, consider S to be the start node and G to be the goal state. From node S we look for a node to expand, and we have nodes A and G, but since it's a uniform cost search, it's expanding the node with the lowest step cost, so node A becomes the successor rather than our required goal node G.

->From A we look at its children nodes B and C. Since C has the lowest step cost, it traverses through node C. Then we look at the successors of C, i.e., D and G.

->Since the cost to D is low, we expand along with node D. Since D has only one child G which is our required goal state we finally reach the goal state D by implementing UFS Algorithm.

->If we have traversed this way, definitely our total path cost from S to G is just 6 even after traversing through many nodes rather than going to G node directly where the cost is 12 and 6<<12(in terms of step cost). But this may not work with all cases.

Key Features and Advantages:

- Optimal Solution: UCS guarantees an optimal solution by consistently exploring paths with the lowest cost. This makes it particularly useful for problems where finding the shortest path is crucial, such as route planning and navigation systems.
- Completeness: UCS is a complete algorithm, meaning that it will find a solution if one exists. It systematically explores the search space, considering all possibilities.
- Applicability: UCS can be applied to a wide range of problems, including puzzle-solving, network routing, and more. It is versatile and can accommodate various types of graphs, including directed and undirected, weighted and unweighted.
- Admissibility: UCS operates under the admissibility principle, meaning it underestimates the cost to reach the goal. This ensures that when it reaches the goal node, the found path is the shortest.
- Memory Efficiency: While UCS may not be as memory-efficient as algorithms like Depth-First Search, it is generally more memory-efficient than A* search, another popular pathfinding algorithm.

Applications of Uniform Cost Search:

- GPS Navigation: UCS is at the core of many GPS navigation systems, helping users find the shortest route between two points while considering traffic conditions and other factors.
- Robotics: In robotics, UCS can be used for path planning and obstacle avoidance, ensuring that a robot reaches its destination while minimizing the cost or time required.
- Network Routing: In computer networks, UCS can help determine the most efficient path for data packets to travel from the source to the destination, considering factors like network congestion and latency.

Disadvantages/ Drawbacks:

- It does not care about the number of steps or finding the shortest path involved in the search problem, and it is only concerned about path cost. This algorithm may be stuck in an infinite loop

Algorithm:

How to do Uniform Cost Search

Algorithm

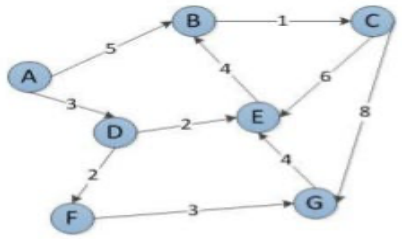
if

- Frontier : empty >Return fail

else

- Add node to frontier.
- Check: node (goal)>solution
- Add node to explored.
- Neighbor s: if not explored >add to frontier
- Else :if was with higher cost replace it .

Example



Solution
Explored : A D B E F C
path: A to D to F to G
Cost = 8

17

Where is Uniform Cost Search used in real life situations?

Uniform Cost Search (UCS) has numerous real-life applications in various domains where finding the shortest path with minimal cost is crucial. Here are some notable real-life applications of UCS:

1. GPS Navigation
2. Robotics
3. Network Routing
4. Game Development
5. Air Traffic Management
6. Natural Language Processing
7. Supply Chain Management
8. Economic Modeling
9. Terrain Exploration
10. Internet Search Engines

Conclusion:

Uniform Cost Search is a powerful and widely applicable algorithm for solving problems that involve finding the shortest path while minimizing the associated cost. Its systematic and admissible nature ensures that it consistently produces optimal solutions. Whether you're building a GPS navigation system, designing a robotics application, or working on network routing, understanding and implementing UCS can lead to more efficient and effective solutions in a variety of domains.

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