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Department of Artificial Intelligence and Data Science

**Course Name – Introduction to Artificial
Intelligence**

II Year / III Semester

Unit 1 A* & AO* Algorithm



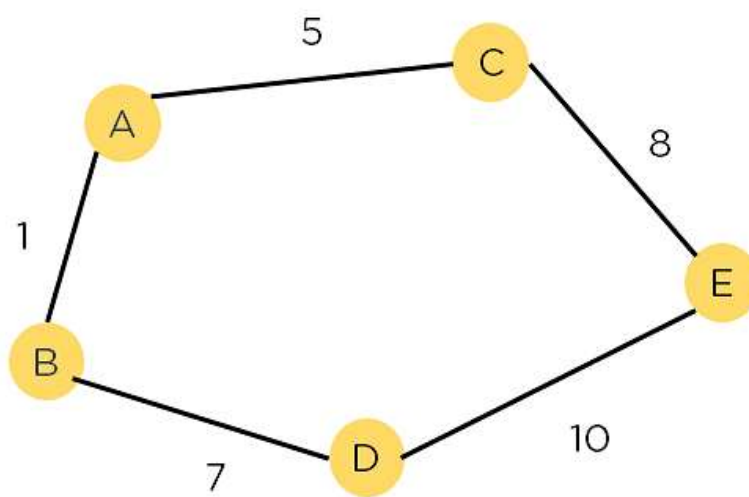
A* Algorithm?

It is a searching algorithm that is used to find the shortest path between an initial and a final point.

It is a handy algorithm that is often used for map traversal to find the shortest path to be taken. A* was initially designed as a graph traversal problem, to help build a robot that can find its own course. It still remains a widely popular algorithm for graph traversal.

It searches for shorter paths first, thus making it an optimal and complete algorithm. An optimal algorithm will find the least cost outcome for a problem, while a complete algorithm finds all the possible outcomes of a problem.

Another aspect that makes A* so powerful is the use of weighted graphs in its implementation. A weighted graph uses numbers to represent the cost of taking each path or course of action. This means that the algorithms can take the path with the least cost, and find the best route in terms of distance and time.



A major drawback of the algorithm is its space and time complexity. It takes a large amount of space to store all possible paths and a lot of time to find them.



Why A* Search Algorithm?

A* Search Algorithm is a simple and efficient search algorithm that can be used to find the optimal path between two nodes in a graph. It will be used for the shortest path finding. It is an extension of Dijkstra's shortest path algorithm (Dijkstra's Algorithm). The extension here is that, instead of using a priority queue to store all the elements, we use heaps (binary trees) to store them. The A* Search Algorithm also uses a heuristic function that provides additional information regarding how far away from the goal node we are. This function is used in conjunction with the f-heap data structure in order to make searching more efficient.

Let us now look at a brief explanation of the A* algorithm.

Explanation

In the event that we have a grid with many obstacles and we want to get somewhere as rapidly as possible, the A* Search Algorithms are our savior. From a given starting cell, we can get to the target cell as quickly as possible. It is the sum of two variables' values that determines the node it picks at any point in time.

At each step, it picks the node with the smallest value of 'f' (the sum of 'g' and 'h') and processes that node/cell. 'g' and 'h' is defined as simply as possible below:

- 'g' is the distance it takes to get to a certain square on the grid from the starting point, following the path we generated to get there.
- 'h' is the heuristic, which is the estimation of the distance it takes to get to the finish line from that square on the grid.



Heuristics are basically educated guesses. It is crucial to understand that we do not know the distance to the finish point until we find the route since there are so many things that might get in the way (e.g., walls, water, etc.). In the coming sections, we will dive deeper into how to calculate the heuristics.



Algorithm

Initial condition - we create two lists - Open List and Closed List.

Now, the following steps need to be implemented -

- The open list must be initialized.
- Put the starting node on the open list (leave its f at zero). Initialize the closed list.
- Follow the steps until the open list is non-empty:
 - 1.Find the node with the least f on the open list and name it “ q ”.
 - 2.Remove Q from the open list.
 - 3.Produce q 's eight descendants and set q as their parent.
 - 4.For every descendant:



Algorithm:

Step 1: Place the starting node into OPEN.

Step 2: Compute the most promising solution tree say T_0 .

Step 3: Select a node n that is both on OPEN and a member of T_0 . Remove it from OPEN and place it in

CLOSE

Step 4: If n is the terminal goal node then levelled n as solved and levelled all the ancestors of n as solved. If the starting node is marked as solved then success and exit.

Step 5: If n is not a solvable node, then mark n as unsolvable. If starting node is marked as unsolvable, then return failure and exit.

Step 6: Expand n . Find all its successors and find their $h(n)$ value, push them into OPEN.

Step 7: Return to Step 2.

Step 8: Exit



AO* Search: (And-Or) Graph

The Depth first search and Breadth first search given earlier for OR trees or graphs can be easily adopted by AND-OR graph. The main difference lies in the way termination conditions are determined, since all goals following an AND nodes must be realized; where as a single goal node following an OR node will do. So for this purpose we are using AO* algorithm.

Like A* algorithm here we will use two arrays and one heuristic function.

OPEN:

It contains the nodes that has been traversed but yet not been marked solvable or unsolvable.

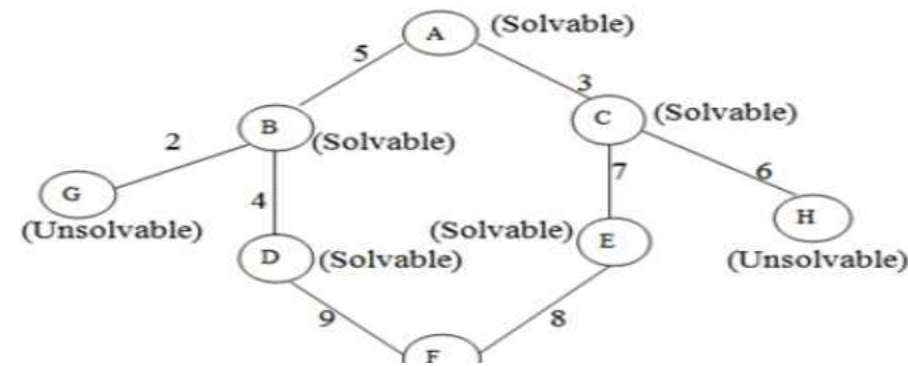
CLOSE:

It contains the nodes that have already been processed.

6 7:The distance from current node to goal node.

Implementation:

Let us take the following example to implement the AO* algorithm.



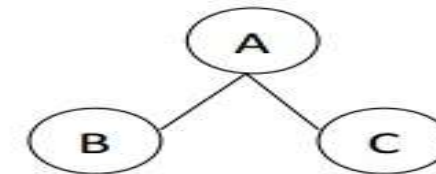
Step 1:

In the above graph, the solvable nodes are A, B, C, D, E, F and the unsolvable nodes are G, H. Take A as the starting node. So place A into OPEN.



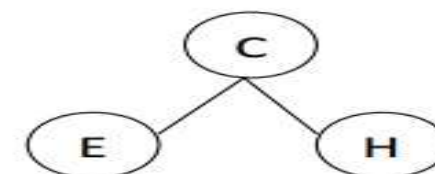
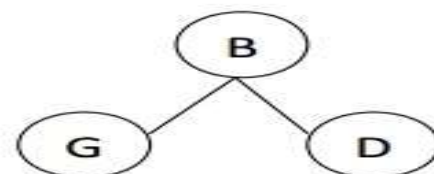
Step 2:

The children of A are B and C which are solvable. So place them into OPEN and place A into the CLOSE.



Step 3:

Now process the nodes B and C. The children of B and C are to be placed into OPEN. Also remove B and C from OPEN and place them into CLOSE.



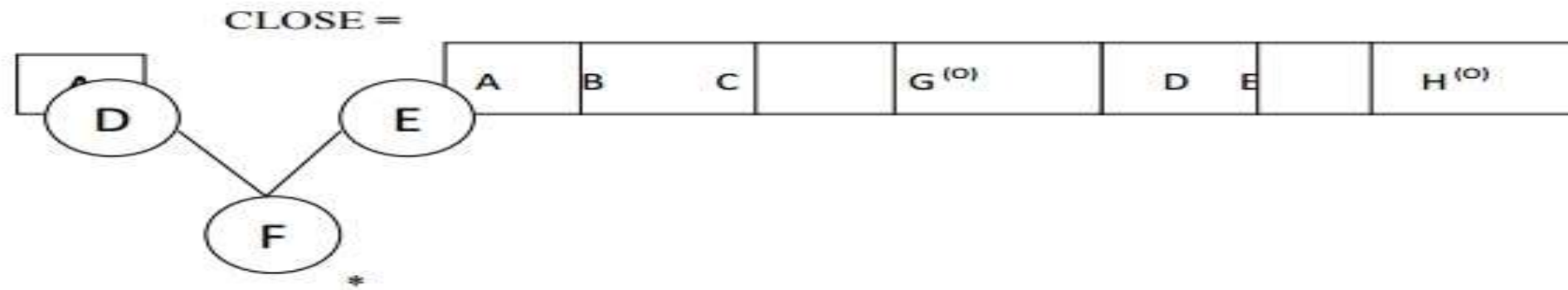
(O)

'O' indicated that the nodes G and H are unsolvable.

Step 4:

As the nodes G and H are unsolvable, so place them into CLOSE directly and process the nodes D and E.

i.e. OPEN =



Step 5:

Now we have been reached at our goal state. So place F into CLOSE.

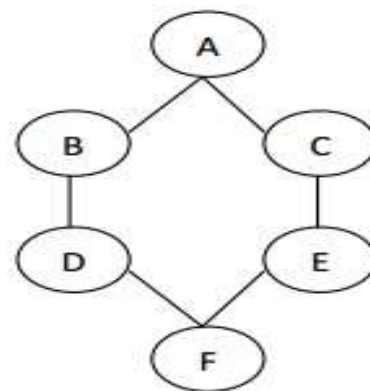


i.e. CLOSE =

Step 6:

Success and Exit

AO* Graph:



Figure

Advantages:

It is an optimal algorithm.

If traverse according to the ordering of nodes. It can be used for both OR and AND graph.

Disadvantages:

Sometimes for unsolvable nodes, it can't find the optimal path. Its complexity is than other algorithms.



i) If finding a successor is the goal, cease looking

ii) Else, calculate g and h for the successor.

successor.g = q.g + the calculated distance between the successor and the q.

successor.h = the calculated distance between the successor and the goal. We will cover three heuristics to do this: the Diagonal, the Euclidean, and the Manhattan heuristics.

successor.f = successor.g plus successor.h

iii) Skip this successor if a node in the OPEN list with the same location as it but a lower f value than the successor is present.

iv) Skip the successor if there is a node in the CLOSED list with the same position as the successor but a lower f value; otherwise, add the node to the open list end (for loop).

Push Q into the closed list and end the while loop.

We will now discuss how to calculate the Heuristics for the nodes.