**AO\* Algorithm**

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**Introduction to the Algorithm:**

Motivation

To approximate the shortest path in real-life situations, like- in maps, games where there can be many hindrances.

**A\* Search** algorithm is one of the best and popular technique used in path-finding and graph traversals. Informally speaking, **A\* Search** algorithms, unlike other traversal techniques, it has “brains”. What it means is that it is really a smart algorithm which separates it from the other conventional algorithms. This fact is cleared in detail in below sections. And it is also worth mentioning that many games and web-based maps use this algorithm to find the shortest path very efficiently (approximation).

Consider a square grid having many obstacles and we are given a starting cell and a target cell. We want to reach the target cell (if possible) from the starting cell as quickly as possible. Here A\* Search Algorithm comes to the rescue. What A\* Search Algorithm does is that at each step it picks the node according to a value – **‘f’** which is a parameter equal to the sum of two other parameters – **‘g’** and **‘h’.** At each step it picks the node/cell having the lowest **‘f’,** and process that node/cell.

We define **‘g’** and **‘h’** as simply as possible below

* **g** = the movement cost to move from the starting point to a given square on the grid, following the path generated to get there.
* **h** = the estimated movement cost to move from that given square on the grid to the final destination. This is often referred to as the heuristic, which is nothing but a kind of smart guess. We really don’t know the actual distance until we find the path, because all sorts of things can be in the way (walls, water, etc.).

**Algorithm:**

// A\* Search Algorithm

**1.** Initialize the open list

**2.** Initialize the closed list put the starting node on the open list (you can leave its f at zero)

**3.** while the open list is not empty

**(a)** find the node with the least **f** on the open list, call it "q"

**(b)** pop q off the open list

**(c)** generate q's 8 successors and set their parents to q

**(d)** for each successor

**i)** if successor is the goal, stop search successor.g = q.g + distance

between successor and q successor.h = distance from goal to successor

successor.f = successor.g + successor.h

**ii)** if a node with the same position as successor is in the OPEN list

which has a lower **f** than successor, skip this successor

**iii)** if a node with the same position as successor is in the CLOSED list

which has a lower **f** than successor, skip this successor otherwise, add the

node to the open list

end (for loop)

**(e)** push q on the closed list

end (while loop)

**Code:**

class Node():

def \_\_init\_\_(self, parent=None, position=None):

self.parent = parent

self.position = position

self.g, self.h, self.f = 0,0,0

def \_\_eq\_\_(self, other):

return self.position == other.position

def astar(maze, start, end):

start\_node = Node(None, start)

start\_node.g = start\_node.h = start\_node.f = 0

end\_node = Node(None, end)

end\_node.g = end\_node.h = end\_node.f = 0

open\_list = []

closed\_list = []

open\_list.append(start\_node)

while len(open\_list) > 0:

current\_node = open\_list[0]

current\_index = 0

for index, item in enumerate(open\_list):

if item.f < current\_node.f:

current\_node = item

current\_index = index

open\_list.pop(current\_index)

closed\_list.append(current\_node)

if current\_node == end\_node:

path = []

current = current\_node

while current is not None:

path.append(current.position)

current = current.parent

return path[::-1] # Return reversed path

# Generate children

children = []

for new\_position in [(0, -1), (0, 1), (-1, 0), (1, 0), (-1, -1), (-1, 1), (1, -1), (1, 1)]: # Adjacent squares

node\_position = (current\_node.position[0] + new\_position[0], current\_node.position[1] + new\_position[1])

# Make sure within range

if node\_position[0] > (len(maze) - 1) or node\_position[0] < 0 or node\_position[1] > (len(maze[len(maze)-1]) -1) or node\_position[1] < 0:

continue

if maze[node\_position[0]][node\_position[1]] != 0:

continue

# Create new node

new\_node = Node(current\_node, node\_position)

# Append

children.append(new\_node)

# Loop through children

for child in children:

# Child is on the closed list

for closed\_child in closed\_list:

if child == closed\_child:

continue

# Create the f, g, and h values

child.g = current\_node.g + 1

child.h = ((child.position[0] - end\_node.position[0]) \*\* 2) + ((child.position[1] - end\_node.position[1]) \*\* 2)

child.f = child.g + child.h

# Child is already in the open list

for open\_node in open\_list:

if child == open\_node and child.g > open\_node.g:

continue

# Add the child to the open list

open\_list.append(child)

def main():

maze = [[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 0, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 0, 0, 0, 0, 0, 0]]

start = (0, 0)

end = (7, 6)

path = astar(maze, start, end)

print(path)

if \_\_name\_\_ == '\_\_main\_\_':

main()

**Output Observed for different Inputs:**

* **Input passed:**

start = (0, 0)

end = (7, 6)

maze = [[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 0, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 0, 0, 0, 0, 0, 0]]

* **Output Obtained:**

[(0, 0), (1, 1), (2, 2), (3, 3), (4, 3), (5, 4), (6, 5), (7, 6)]

* **Input passed:**

start = (3, 4)

end = (8, 5)

maze = [[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],

[0, 0, 0, 0, 1, 1, 1, 1, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 1, 0, 0],

[0, 0, 0, 0, 1, 0, 0, 1, 0, 0],

[0, 0, 1, 0, 1, 0, 1, 0, 0, 0],

[0, 0, 1, 0, 1, 0, 1, 0, 0, 0],

[0, 0, 0, 0, 0, 0, 1, 0, 0, 0]]

* **Output Obtained:**

[(3, 4), (4, 3), (5, 3), (6, 3), (7, 3), (8, 3), (9, 4), (8, 5)]