

A* Pathfinding Algorithm Documentation & Pseudocode

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Project Description:

This project implements the A* pathfinding algorithm to find the shortest path in a grid. It includes:

- Console output showing step-by-step exploration.
- Pygame visualization of visited nodes and final path.

Extra Features:

- Supports 8-direction movement (diagonal moves included).
- Human-like visualization with slightly random colors for visited nodes.
- Step-by-step messages in the console.

Assumptions:

- Grid is a 2D list: 0 = free cell, 1 = obstacle.
- Start and Goal positions are predefined.
- Movement allowed in 8 directions (can remove diagonals for 4-directional movement).
- If no path exists, an empty path is returned.
- Delays are added (time.sleep in console, clock.tick in Pygame) for smooth animation.
- Straight moves cost 1, diagonal moves cost 1.4.

Pseudocode:

Function Heuristic(node, goal):

 Return Euclidean distance between node and goal

Function A_Star(grid, start, goal):

 open_list = [(0, start)]

 came_from = {}

 g_score[start] = 0

 visited = []

 While open_list is not empty:

 current = node with lowest f_score

Add current to visited

If current == goal:

Reconstruct path from came_from

Return visited, path

Foreach neighbor of current (4 or 8 directions):

If neighbor is valid and not obstacle:

tentative_g = g_score[current] + movement_cost

If tentative_g < g_score[neighbor]:

Update g_score[neighbor]

came_from[neighbor] = current

Add neighbor to open_list with f = tentative_g + heuristic(neighbor, goal)

Return visited, empty path

How It Works: 1. Start at the start node and explore neighbors using a priority queue (lowest $f = g + h$). 2. Console prints each visited node, Pygame shows it visually with light random shades. 3. Euclidean distance is used as the heuristic (works for diagonals). 4. When the goal is reached, the final path is reconstructed. 5. Symbols in console: S = Start, G = Goal, # = Obstacle, . = Visited, O = Path. 6. Pygame colors: green = start, red = goal, blue = path, light random = visited nodes.

How to Build & Run: 1. Install Pygame: `pip install pygame`
2. Save the script as `astar_pygame_console.py`.
3. Run the program: `python astar_pygame_console.py`
4. Observe step-by-step exploration in console and smooth animation in Pygame.

Customization:

- Modify grid, start, or goal variables in the script.
- Adjust `time.sleep` in console or `clock.tick` in Pygame for animation speed.
- Remove diagonal moves in directions list for 4-directional movement.

Output Example:

Console:

Exploring node (0, 0) Exploring node (1, 0) ... Final Path: S
. O . O # # . # Legend: S=Start, G=Goal, #=Obstacle,
.=Visited, O=Path

Pygame:

- Blue = Final path
- Light blue = Visited cells
- Green = Start
- Red = Goal
- Black = Obstacles

End of Documentation & Pseudocode