

```
[1]: import heapq

class PuzzleState:
    def __init__(self, board, goal, g=0, h=0):
        self.board = board
        self.goal = goal
        self.g = g
        self.h = h
        self.f = g + h

    def __lt__(self, other):
        return self.f < other.f

    def __eq__(self, other):
        return self.board == other.board

    def __hash__(self):
        return hash(str(self.board))

    def get_blank_pos(self):
        for i in range(3):
            for j in range(3):
                if self.board[i][j] == 0:
                    return i, j

    def generate_neighbors(self):
        neighbors = []
        x, y = self.get_blank_pos()
        moves = [(0, 1), (0, -1), (1, 0), (-1, 0)]
        for dx, dy in moves:
            new_x, new_y = x + dx, y + dy
            if 0 <= new_x < 3 and 0 <= new_y < 3:
                new_board = [row[:] for row in self.board]
                new_board[x][y], new_board[new_x][new_y] = new_board[new_x][new_y], new_board[x][y]
                neighbors.append(new_board)
        return neighbors

# ----- Misplaced Tiles Heuristic -----
def misplaced_tiles(board, goal):
    return sum(
        1 for i in range(3) for j in range(3)
        if board[i][j] != 0 and board[i][j] != goal[i][j]
    )
```

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Python (Pycode)

```
# ----- Misplaced Tiles Heuristic -----
def misplaced_tiles(board, goal):
    return sum(
        1 for i in range(3) for j in range(3)
        if board[i][j] != 0 and board[i][j] != goal[i][j]
    )

# ----- A* Algorithm -----
def a_star(initial, goal):
    open_list = []
    closed_set = set()

    h0 = misplaced_tiles(initial, goal)
    start_state = PuzzleState(initial, goal, g=0, h=h0)
    heapq.heappush(open_list, start_state)

    while open_list:
        current = heapq.heappop(open_list)

        if current.board == goal:
            print("Goal reached with cost:", current.g)
            return True

        closed_set.add(tuple(map(tuple, current.board)))

        for neighbor in current.generate_neighbors():
            if tuple(map(tuple, neighbor)) in closed_set:
                continue

            g_new = current.g + 1
            h_new = misplaced_tiles(neighbor, goal)
            new_state = PuzzleState(neighbor, goal, g=g_new, h=h_new)
            heapq.heappush(open_list, new_state)

    return False

# ----- Example Run -----
initial_state = [
    [1, 2, 3],
    [4, 0, 6],
    [7, 5, 8]
]

goal_state = [
```

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JupyterLab Python (Pycode)

```
closed_set = set()

h0 = misplaced_tiles(initial, goal)
start_state = PuzzleState(initial, goal, g=0, h=h0)
heapq.heappush(open_list, start_state)

while open_list:
    current = heapq.heappop(open_list)

    if current.board == goal:
        print("Goal reached with cost:", current.g)
        return True

    closed_set.add(tuple(map(tuple, current.board)))

    for neighbor in current.generate_neighbors():
        if tuple(map(tuple, neighbor)) in closed_set:
            continue

        g_new = current.g + 1
        h_new = misplaced_tiles(neighbor, goal)
        new_state = PuzzleState(neighbor, goal, g=g_new, h=h_new)
        heapq.heappush(open_list, new_state)

    return False

# ----- Example Run -----
initial_state = [
    [1, 2, 3],
    [4, 0, 6],
    [7, 5, 8]
]

goal_state = [
    [1, 2, 3],
    [4, 5, 6],
    [7, 8, 0]
]

print("A* with Misplaced Tiles Heuristic")
a_star(initial_state, goal_state)

A* with Misplaced Tiles Heuristic
Goal reached with cost: 2

[1]: True
```

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