Artificial Intelligence (AL-2002)
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Final Project Report

"Optimized Pathfinding: Karachi Market Explorer & A* Maze Escape"

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Introduction

In this project, we examine the application of Artificial Intelligence (AI) algorithms in addressing two separate but related problems: “Urban path finding in complex environments,” and “Interactive maze solving using informed search.”
The system is developed using Python and Streamlit and provides an interactive interface through which users can experience the real-world implications of AI in decision-making (Karachi traffic navigation) as well as in puzzle-based (Escape Room) challenges.

Objectives

Design a system using Streamlit that has a clean, intuitive, and a responsive user interface
Enable comparative analysis on the effectiveness of different AI techniques in pathfinding. Demonstrate the application of A* and CSP algorithm in real and virtual search problem scenarios. Visualize how AI under various constraints dynamically computes solutions for optimal accuracy and efficiency.

The Karachi Market Path

Karachi, Pakistan’s largest city and economic hub, presents a unique challenge for navigation due to its dense network of roads, markets, and congested alleyways. The **Karachi Market Path Finder** addresses this challenge by implementing AI-based algorithms to determine optimal routes between markets. The system models the city as a **graph**, where:

- **Nodes** represent markets
- **Edges** represent roads
- **Weights** reflect distances, accessibility, and traffic conditions

By leveraging **A*** and **Constraint Satisfaction Problem (CSP)** algorithms, the system ensures not only shortest-path calculations but also constraint-based decision-making such as avoiding closed or restricted roads.

A* Algorithm vs. UCS (Comparative Analysis):

Both algorithms contribute distinct strengths depending on the scenario:

A* Algorithm:

Strengths:

1. Combines path cost and heuristic estimate to efficiently find optimal paths.
2. Prioritizes exploration of the most promising routes
3. Well-suited for dynamic environments with changing conditions

Applications:

1. Ideal for scenarios prioritizing **minimum travel time or distance**
2. Used effectively in the Karachi simulation for quick and adaptive routing

Uniform Cost Search (UCS)

Strengths:

1. Guarantees the optimal path based on actual cost from the start node (uses only g(n)).
2. Does not require a heuristic—useful when one is not available or too hard to define.
3. Complete and optimal for all graphs with positive edge weights.

Applications:

1. Ideal where the exact path cost matters, and heuristics cannot be trusted (e.g., logistics, delivery routing).
2. Used in scenarios where all edge costs are known and fixed.
3. Works best in simpler or smaller maps where computation time is less of a concern.

A* Escape Room Challenge

The **A* Escape Room Challenge** is a gamified module that demonstrates the effectiveness of AI in puzzle solving. Players must escape a maze-like environment filled with locked doors and obstacles. The system applies the **A*** algorithm to dynamically calculate the shortest escape route based on:

- Start and goal positions
- Obstacles or puzzles as barriers
- Movement cost and heuristic distance

This setup simulates a real-world search problem in a controlled environment, allowing users to visualize how A* makes decisions step-by-step. The algorithm ensures the chosen path is both **optimal** and **efficient**, reinforcing core AI search concepts in an engaging format.

Conclusion

The Karachi Market Path Finder and A* Escape Room Challenge collectively showcase how AI algorithms can be applied to both real-world and virtual problem-solving.

- A* excels in fast and dynamic navigation. Its application in Karachi's complex road network proves its scalability and effectiveness.
- CSP is better suited for constraint-heavy tasks, ensuring safe and rule-compliant routing. It enhances decision-making in scenarios where avoiding prohibited paths is critical.
- The Escape Room module provides an intuitive understanding of how AI computes solutions in maze-like puzzles.

These implementations highlight the growing importance of AI-driven path optimization in urban mobility, smart systems, and interactive game environments. As urban infrastructure becomes increasingly complex, such intelligent systems will be essential in shaping the future of navigation and decision automation.