Artificial Intelligence (AL-2002)
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Final Project Report

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

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Introduction

This project demonstrates the use of Artificial Intelligence (AI) algorithms to solve two problems: market pathfinding in complex environments and interactive maze solving. Developed using Python and Streamlit, the system provides a user-friendly interface that showcases AI-driven decision-making in both real-world and abstract settings.

Objectives

Design a system using Streamlit that features a clean, intuitive, and responsive user interface. The system should enable comparative analysis of the effectiveness of various AI techniques in pathfinding. It must demonstrate the application of the A* and Uniform Cost Search (UCS) algorithms in diverse search scenarios. Additionally, the system should visualize how AI dynamically computes solutions under different constraints to achieve 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 **Uniform Cost Search (UCS)** algorithms, the system ensures best shortest-path calculations.

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* together illustrate the practical application of AI algorithms in both real-world and simulated problem-solving environments.

- **A*** demonstrates rapid and adaptive navigation capabilities. Its deployment within Karachi's intricate road network showcases its scalability and effectiveness in handling dynamic challenges.
- **Uniform Cost Search (UCS)** offers precise, cost-efficient pathfinding. Its consistent performance in structured and resource-aware scenarios makes it particularly suitable for tasks requiring guaranteed optimal solutions.
  The **Escape Room** module serves as an intuitive and engaging example of how AI can compute solutions to maze-like puzzles, enhancing conceptual understanding through visualization.

These implementations emphasize the growing significance of AI-driven path optimization in domains such as urban mobility, intelligent systems, and interactive gaming. As urban infrastructures grow increasingly complex, such intelligent systems will play a vital role in shaping the future of navigation and automated decision-making.