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Eco-Friendly Delivery Route Optimization Service

Overview

This report outlines the development of a Python-based AI delivery route optimizer that aims to reduce the carbon footprint of inter-city deliveries across the UK. With the rise in e-commerce and the demand for more sustainable logistics, this system provides a foundation for eco-aware delivery planning by leveraging various search algorithms and simulated real-world conditions like traffic. The core of the system is an intelligent route finder that adapts to changing environments and attempts to find the best possible delivery paths between major cities.

All that there is to now, can be found in this GitHub Repository:
https://github.com/marianor03/Eco-friendly-Delivery-Service

How the Program Works

The program begins by prompting the user to select a starting city and a destination city from a predefined list of delivery points (e.g., Manchester, Inverness, Edinburgh). These cities are interconnected through roads with predefined distances.

Once the user inputs the cities, the program runs several classical and advanced search algorithms to compute the optimal route:

1. **Breadth-First Search (BFS)**
2. **Depth-First Search (DFS)**
3. **Dijkstra's Algorithm**
4. **A Search***
5. **Simulated Annealing** (Advanced Optimization)

The distances are then adjusted with simulated traffic data to reflect realistic delays. Simulated Annealing is applied to optimize the path further, even considering potentially worse short-term paths to escape local optima.

Technical Features

- **Graph-Based Map:** Cities and routes are represented as a dictionary-based graph, allowing for easy expansion.
- **Dynamic Traffic Simulation:** Each city's connection distances are multiplied by a random factor (0.8 to 1.2), mimicking real-life congestion.

- **Search Algorithms:**
  - *BFS and DFS* explore all paths with different strategies.
  - *Dijkstra and A* Search* aim for the shortest paths using cost-based decisions.
  - *Simulated Annealing* introduces randomness and probability for global optimization.
- **User Interaction:** Simple command-line interface prompts user input and prints all routes with corresponding distances.
- **Validation Checks:** Prevents invalid inputs and guards against calculation errors.

Ethical Considerations

In designing this system, several ethical factors were taken into account:

- **Sustainability Focus:** The core objective of the project is to reduce the carbon footprint of deliveries. Choosing shorter or less congested paths helps reduce fuel consumption and emissions, aligning with sustainability goals and the UN's Sustainable Development Goal 13 (Climate Action) [UN, 2015].
- **Data Privacy:** Although the system does not currently use real user or location data, future iterations could. It is essential that user location data be anonymized and handled in compliance with GDPR regulations to ensure privacy [ICO, 2021].
- **Algorithmic Transparency:** All search methods are deterministic and explainable, with no black-box machine learning models. This transparency ensures the decision-making process can be reviewed and trusted [Floridi et al., 2018].
- **Accessibility:** By building the system with a simple interface, we ensure it is accessible to users with minimal technical background, promoting inclusive design.

Reflections and Improvements

Working on this project really emphasized how essential efficient pathfinding is in real-world logistics. Initially, it was tempting to rely only on Dijkstra's Algorithm or A*, but

incorporating Simulated Annealing made it clear that non-traditional methods offer powerful alternatives, especially when faced with unpredictable factors like traffic.

Challenges included:

- Handling small paths that could not be optimized (e.g., too few cities).
- Forcing variation in the Simulated Annealing path without breaking logic.

Future improvements could include:

- Integrating live traffic or weather data via APIs.
- Adding carbon emission calculations per route.
- Visualizing the graph and chosen path using a GUI or plotting library.
- Incorporating renewable energy and EV-specific routing as factors.

Conclusion

This route optimization system showcases how AI and classic algorithm design can be blended to support sustainable logistics. It proves that even simple simulations of real-world dynamics can significantly alter the best path choices. With further development, this program could evolve into a real-time decision-making tool for environmentally-conscious delivery companies. Overall, it's a strong step toward greener, smarter routing solutions.

References

- UN. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development*. United Nations. https://sdgs.un.org/goals
- ICO. (2021). *Guide to the General Data Protection Regulation (GDPR)*. Information Commissioner's Office. https://ico.org.uk
- Floridi, L., Cowls, J., Beltrametti, M. *et al.* AI4People—An Ethical Framework for a Good AI Society: Opportunities, Risks, Principles, and Recommendations. *Minds & Machines* **28**, 689–707 (2018). https://doi.org/10.1007/s11023-018-9482-5

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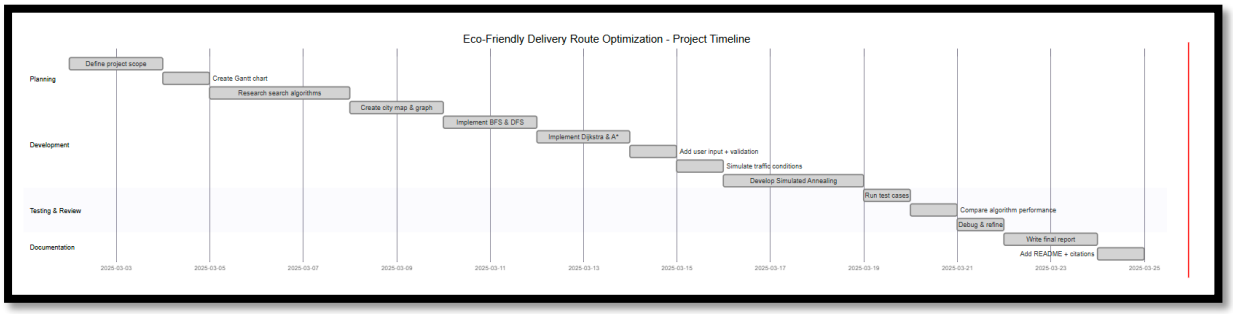
Gallery

Gantt Chart:



Flow Chart: