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Optimizing Food Delivery Routes with Dijkstra's Algorithm: An Analysis

In the fast-paced food delivery industry, efficient route planning is essential. Optimized delivery paths reduce travel time, fuel consumption, and vehicle wear, while enhancing customer satisfaction. Dijkstra's algorithm, a classic shortest-path algorithm, offers a structured approach for determining optimal delivery routes within a network.

Dijkstra's algorithm is well-suited for modeling a road network as a graph, where nodes represent intersections or delivery points, and edges represent roads weighted by distance or travel time (Hashim & Hasson, 2024). From a central hub, the algorithm calculates the shortest path to each destination. Its compatibility with non-negative edge weights and both directed and undirected graphs supports its application in real-world road systems. However, its standard form only handles one-to-one routing, not multi-stop deliveries—a scenario more akin to the Traveling Salesperson Problem (Shah, Li, & Liu, 2024).

Implemented with a priority queue, Dijkstra’s algorithm has a time complexity of O((V + E) log V). Integrating real-time traffic data means edge weights fluctuate, potentially requiring frequent recalculations or updates to the priority queue (Tsitsiashvili, 2024). These fluctuations can destabilize routes, forcing the system to re-optimize even with minor changes. To manage computation time—ideally under a minute for real-time applications—hardware acceleration and optimization thresholds may be necessary (Hashim & Hasson, 2024).

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| **Operation** | **Without Priority Queue** | **With Priority Queue** |
| Initializing distances | O(V) | O(V) |
| Finding min-distance vertex | O(V) | O(log V) |
| Relaxing adjacent vertices | O(V) | O(log V) |
| **Total Time Complexity** | O(V^2) | O((V + E) log V) |

Real-world food delivery involves more than just distance: time windows, order priorities, restaurant prep times, courier capacities, and road conditions all influence routing. Standard Dijkstra’s does not account for these constraints. Modifications are needed to incorporate such factors into routing logic (Shah, Li, & Liu, 2024). For instance, integrating preferences and capacity constraints—like in shared e-mobility systems—demonstrates how Dijkstra’s can be adapted for complex logistical environments. No routing algorithm can overcome all external obstacles. Delays in food prep, inaccurate traffic data, or customer unavailability impose unavoidable inefficiencies. These factors form a lower bound on delivery performance, regardless of algorithm sophistication (Tsitsiashvili, 2024).

While Dijkstra's algorithm is deterministic and reliable (Hashim & Hasson, 2024), minor changes in link weights can lead to drastically different paths, impacting stability (Tsitsiashvili, 2024). In dynamic contexts, stability is key to prevent courier confusion. Approaches in shared mobility and variational problems show that Dijkstra's can be adapted to include custom weights, constraints, and multi-modal routing (Arunthong et al., 2024; Shah, Li, & Liu, 2024).

Dijkstra's algorithm remains a valuable foundation for route optimization, but its direct use in food delivery is limited by real-world complexity. A practical system should use Dijkstra’s as a core component within a broader framework capable of handling real-time traffic, multi-stop routing, and service-level constraints. Modifying the algorithm or integrating it with heuristics and real-time systems will enhance its practicality for food delivery logistics.

**References:**

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