Project Proposal: Bidirectional Dijkstra's Algorithm

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Paper Details

Title: Bidirectional Dijkstra's Algorithm is Instance-Optimal
Authors: Bernhard Haeupler et al.
Conference: SOSA 2025
DOI: `https://epubs.siam.org/doi/10.1137/1.9781611978315.16`

Summary

This paper proves the **instance-optimality** of bidirectional Dijkstra's algorithm for shortest-path computations, showing that no correct algorithm outperforms it by more than a constant factor.

Key contributions:

- Formal proof of instance-optimality.

- Near-optimal guarantees for unweighted graphs.

- Comparative analysis with A* search.

Justification and Feasibility

Relevance: Establishes performance bounds for graph algorithms; applicable in routing systems.
Implementation: Pseudocode provided, enabling direct translation into code.
Resources: No reference implementation; datasets available (Kaggle, OpenStreetMap).

Implementation Plan

Algorithm: Implements bidirectional search with adjacency lists and priority queues.
Verification: Compare with standard Dijkstra and A*; validate with real-world graphs.
Challenges and Mitigation:

Challenge	Mitigation
Termination conditions	Step-by-step validation
Bidirectional sync	Thread-safe structures
Large graphs	Progressive testing

Team Responsibilities

Qurba Mushtaq: Algorithm implementation, benchmarking, paper analysis.
Hiba Shahid: Graph generation, result analysis, report writing.

GitHub Repository

URL: `https://github.com/HibaShahidA/Bidirectional-Dijkstra`
Structure: `/src` (code), `/data` (datasets), `/benchmarks` (performance scripts), `/docs` (notes).

Next Steps

1. Implement Algorithm 2.

2. Develop graph generators.

3. Compare with Dijkstra and A*.

4. Analyze and document results.