Cambridge Garbage Vehicle Routing

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Project Overview

EXECUTIVE SUMMARY

Refuse (garbage) vehicles are frequently employed to transport MSW from households to waste treatment facilities (landfills, incinerators, and transfer stations). So, a Capacitated Vehicle Routing Problem (CVRP) using integer optimization was explored over 13 Cambridge neighborhoods to optimize garbage vehicle routing.

PROBLEM STATEMENT

Minimize operating costs (or emissions) of all vehicles across all routes whilst ensuring that garbage is fully removed from each neighborhood and that vehicle capacities are not exceeded.

WHY DO WE CARE?

Garbage vehicle routes are not usually optimized to minimize operating costs. Another issue is the poor fuel economy and emissions of these vehicles, which are harmful to nature.

Data

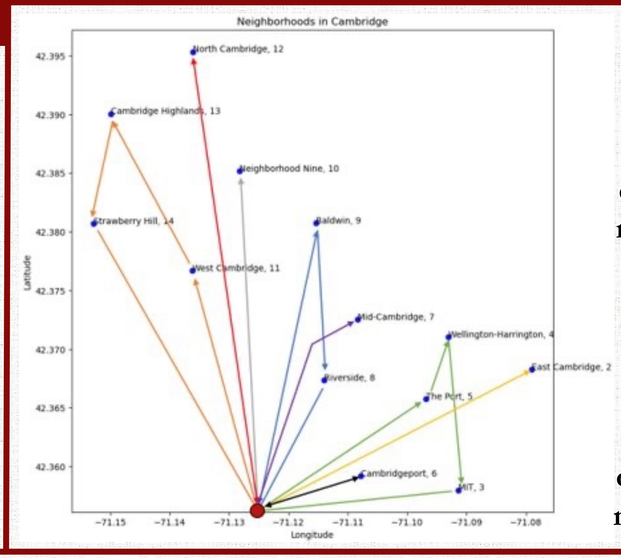
- Neighborhood locations
- Haversine distances
- Waste produced per neighborhood
- Route Costs
- Emissions

Formulation

$$min \sum_{k=1}^{v} \sum_{i=1}^{15} \sum_{j=1}^{15} c_{ijk} x_{ijk}$$

1. No travel from a node to itself
2. No direct travel between landfill nodes 1 and 15
3. No outflow from terminal landfill node 15
4. No inflow into landfill node 1
5. Each vehicle departing from landfill node 1 goes to exactly 1 neighborhood
6. Each neighborhood *j* is visited exactly once
7. Each vehicle must return to terminal landfill node 15
8. Vehicle capacity constraint
9. Each vehicle departs from the same node in which it entered
10. Miller-Tucker (MTZ) subtour elimination
11. Binary decision variable x_{ijk}

Key Findings



Cost savings over baseline model: 0.86%

Emission reduction over baseline model: 0.85%

Practical Impact

0.86% Savings
Reallocate funding

0.85% Reductions
3rd highest mean fuel consumption annually and 2.5 MPG fuel economy

What to do if we had Another Week?

1. **Robust Optimization**: Factor uncertainty into costs and emissions
2. **Restructure Data & Incorporate "Trade-Off"**

$$min \sum_{k=1}^{v} \sum_{i=1}^{15} \sum_{j=1}^{15} \lambda c_{ijk} x_{ijk} + (1-\lambda) \varepsilon_{ijk} x_{ijk}$$

3. **Disaggregate Neighborhoods & Include More Waste Treatment Facilities**
4. **Compare with Column Generation Methods**