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Project Title

Assessing and Improving Efficiency of Snowplowing Operations via Data and Analytics

University

University of Utah

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Research Needs

The core objective of this research is to improve the efficiency of UDOT's snowplowing operations. First, we will leverage GPS and GIS data to evaluate the current efficiency of UDOT's operations. Second, we will seek to improve the plowing operations with the existing resources. This will be achieved by optimizing snowplow routes and salt dome locations. These improvements are expected to reduce turnaround time by 5% to 10%. Lastly, we will develop a software to allow UDOT to efficiently manage state's plowing operations.

Research Objectives

The objective of this research project is threefold:

1. Evaluate the current snowplowing operations in Utah;
2. Improve efficiency of UDOT's snowplowing operations through route optimization;
3. Develop a software (GIS Tool) to manage UDOT's plowing operations.

Research Methods

1. Evaluation of the current snowplowing operations: Making full use of historical data, this research will evaluate the snow removal operation efficiency and assess the utilization of existing resource. To this end, we will leverage all the available UDOT data, including snowplow AVL data and GIS layers of salt dome locations and local road network. This project will use Region 1 as a testbed for data gathering and modeling, with a possibility of extending the entire analytical framework nationwide.

2. Exploring ways to improve efficiency of snowplowing operations with the existing resources

    a. Optimizing Snowplow Routes for Region 1: We will implement a model to assign vehicle plows to roads, while accounting for all operational constraints. The model will be a variation of the Min–max k-Chinese Postman Problem (MM k-CPP). It will quickly find near-optimal routes given the fleet, road network, and locations of salt domes.

    b. Optimizing Locations of Salt Domes in Region 1: The MM k-CPP algorithm will be also used to find the optimal locations of new salt domes. Using this algorithm, we will determine the optimal locations of any additional salt domes, and the optimum routes for snowplows given the newly-added salt piles.

    c. Optimizing Allocation of Snowplows: We will further find the optimal allocation of vehicles across regions. The team will determine the optimal allocation of vehicles, as well as optimal routes for snowplows.

3. Software (GIS Tool): The team will provide a tool to UDOT that can be used to do "what-if" scenario analysis to determine optimum routes if anything changes in the field (e.g., a vehicle breaks or another vehicle becomes available).

Expected Outcomes

There will be three main deliverables. The first deliverable is detailed evaluation of the current snowplow routing operations, which will be based on the available UDOT data (i.e., AVL, salt dome locations, and vehicle info). The current efficiency will be expressed using various performance measures (e.g., turnaround time, total vehicle-hours, total vehicle-miles). The second deliverable is a list of recommendations for improving the efficiency (i.e., optimal plowing routes for Region 1, optimal locations of new salt piles). The third deliverable will be an ArcGIS tool that can be used to quickly determine efficient routes if anything changes in the field (e.g., a vehicle breaks or another vehicle becomes available).

Additional deliverables includes: final report, journal articles, conference proceedings, video/audio presentation summarizing the project, and computer animations intended to disseminate results to wider audience.

Relevance to Strategic Goals

Primary strategic goal: Safety. Efficient snow plowing is of paramount importance for ensuring safe traffic operations. The optimization algorithms and software developed as part of the proposed project will result in quicker snow removal and thereby reduce the chances of traffic accidents occurring.

Secondary strategic goal: Economic Competitiveness. The proposed optimization algorithms and software for routing snow plow trucks are expected to reduce the cost of plowing operations by at least 5% and thereby reduce state expenditures.

Educational Benefits

The PI of this project is currently teaching a graduate level class "CVEEN 6530: Quantitative Methods in Transportation Operations". It is expected that the developed algorithms, methods, and case studies in this project will be directly converted into new course materials for this project. In addition, a number of selected undergraduate and graduate students will be participating in different steps of this project including data collection, processing, and validating the obtained results.

Technology Transfer

The technology transfer process for this project will take place through three major channels: 1) publishing (presenting) research results in scholarly journals (conference proceedings); 2) direct interactions with UDOT personnel as the potential end users for the results of this study; and 3) development of a software tool to manage UDOT's snowplowing operations, 4) Webinar for MPC to make other states aware of the project and benefits of optimized plowing.

Work Plan

- [1 month] Review of literature and data
    - Review of the scientific literature on snowplow operational assessment
    - Review of the available UDOT data (e.g., AVL, GIS layers of the road network, information about the fleet, important operational constraints).
- [2 months] Efficiency evaluation based on the AVL, GIS, vehicle info and other data provided by the UDOT.
    - The team will evaluate the efficiency of the snow removal operations based on the historical data and propose several performance measures to present to the TAC
    - A particular focus will be placed on severe snow storms scenario for data collection
- [3 months] Improving efficiency by optimizing routes in Region 1
    - The team will implement and refine snowplow routing algorithms that account for all operational constraints
    - The team will determine optimal routes for Region 1 given the existing salt pile locations and fleet
    - The team will provide visualizations and animations of the optimal routes for Region 1
- [2 months] Improving efficiency by optimizing salt dome locations in Region 1

    - The team will determine the optimum locations of new salt domes and the optimal routes
    - The team will provide visualizations and animation of the obtained solutions
    - The team will additionally consider the problem of determining staffing levels and allocating vehicles
- [4 months] GIS-based tool to generate routes in case of any changes to the system (e.g., Region 1 vehicle breaks)
    - The team will provide an ArcGIS toolbox for UDOT to use to find optimum routes in case anything changes in the system (e.g., a vehicle breaks or another vehicle becomes available).
- [2 months] Final report, journal articles, conference proceedings, video/audio presentation. The team will provide all the documentation and computer codes to UDOT

Project Cost

Total Project Costs:	$90,000
MPC Funds Requested:	$40,000
Matching Funds:	$50,000
Source of Matching Funds:	Utah Department of Transportation, financial support