Strategic Development of Graphical User Interface Tools for Enhancing Transportation Mobility Among Vulnerable Groups During Pandemics

Technology Transfer Activities

by

Yuche Chen
300 Main St., Columbia, SC 29208
University of South Carolina
Phone: (803) 777-9105; *E-mail:* chenyuc@cec.sc.edu

Xuanke Wu, Oak Ridge National Laboratory
Juan Caicedo, University of South Carolina
Yu Qian, University of South Carolina

December 2024

Center for Connected Multimodal Mobility (C^2M^2)

CLEMSON UNIVERSITY

SC State University | The Citadel, The Military College of South Carolina | University of South Carolina | Benedict College

200 Lowry Hall
Clemson, SC 29634

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated in the interest of information exchange. The report is funded, partially or entirely, by the Center for Connected Multimodal Mobility (C^2M^2) (Tier 1 University Transportation Center) Grant, which is headquartered at Clemson University, Clemson, South Carolina, USA, from the U.S. Department of Transportation's University Transportation Centers Program. However, the U.S. Government assumes no liability for the contents or use thereof.

Table of Contents

Technology Transfer Activities

1 Outputs

This project aims to improve the quality of life for people with disabilities and the elderly by addressing social exclusion, accessibility, and mobility issues with a strategic GUI to assist accommodations of ride-sharing vehicle facility planning, establishment, as well as life-cycle maintenance and management effectively.

1.1 Output #1

Based on the project's results, we successfully develop a comprehensive GUI application that streamlines the ride-sharing system's scheduling and optimization processes. In addition to the application, we produced a detailed technical report documenting the methodologies, algorithms, and key findings of the project, providing a thorough analysis for future reference. A user guide is also prepared, offering clear instructions and support for users to navigate the application and fully utilize its features. To share our findings and insights, we delivered an engaging presentation at the C^2M^2 8th Annual Fall Conference, where we showcased the project's outcomes, demonstrated the application's capabilities, and discussed the potential impact on improving ride-sharing systems. These efforts collectively contribute to advancing the practical use of optimization models in transportation systems while fostering collaboration and knowledge exchange within the industry.

1.2 Output #2

The developed GUI application successfully integrates complex algorithmic functions into a single, accessible interface, making it easier for users to interact with and utilize advanced optimization techniques without requiring deep technical expertise. By providing an intuitive and user-friendly design, the application facilitates effective decision-making in car-sharing operations, allowing operators to optimize vehicle allocation, route planning, and scheduling in real time. This integration of sophisticated algorithms ensures that users can quickly analyze data, make informed decisions, and adapt to changing conditions, ultimately enhancing the efficiency and reliability of the car-sharing system. Moreover, the simplicity of the interface ensures that even users with minimal experience in optimization or programming can effectively leverage the tool, contributing to its broader adoption and practical application in real-world scenarios.

1.3 Output #3

In this project, we conduct comprehensive testing and analysis of car-sharing system operations for vulnerable groups during pandemics in four metropolitan areas of South Carolina: Charleston, Clemson, Columbia, and Myrtle Beach. We examine various factors, such as accessibility, scheduling efficiency, and resource allocation, to ensure that the car-sharing systems can effectively meet the needs of elderly individuals, people with disabilities, and others facing mobility challenges during times of crisis. The results from these case studies provide valuable insights into how car-sharing systems can be optimized to support vulnerable populations under challenging circumstances.

Furthermore, the approach we developed is highly adaptable and can be easily applied to other areas with minimal modifications to the network data. By adjusting parameters such as geographical coverage, demand patterns, and fleet sizes, the model can be tailored to suit the

specific needs of different regions, making it a versatile solution for improving transportation access in diverse communities, particularly during emergencies like pandemics.

2 Outcomes

By focusing on user-friendliness and comprehensive functionality, the developed application stands as a significant advancement in supporting public transportation planning and management.

2.1 Outcome #1

This project aims to simplify complex optimization algorithms used for ride-sharing system scheduling, making them more accessible and practical for real-world applications. By streamlining these algorithms, the project reduces the technical barriers typically associated with advanced optimization models, allowing users to more easily leverage the system's capabilities. Additionally, the project provides user-friendly tools designed for seamless interaction, minimizing the need for extensive technical training. With an intuitive interface and straightforward functionality, users can effectively implement the system with minimal effort. In most cases, only a single training demo is required to ensure successful implementation, further enhancing its accessibility and ease of adoption across different user groups.

2.2 Outcome #2

GUI development for the application in this project was implemented using Tkinter, providing a user-friendly interface to interact with the system. This choice ensures accessibility and ease of use for a broader audience, including users with limited technical backgrounds. In addition to GUI development, the project incorporates advanced sampling and optimization techniques such as Monte Carlo Sampling, Sample Average Approximation (SAA), and Rolling Horizon (RH) methods. These methodologies enhance the system's ability to handle uncertainty, improve decision-making efficiency, and optimize resource allocation. By integrating these advanced approaches, the project delivers a robust, scalable solution that bridges technical sophistication with practical usability.

2.3 Outcome #3

The original ride-sharing optimization models have been extensively studied, demonstrating their potential for improving transportation efficiency. However, many of these models are complex and require significant technical expertise to implement, limiting their practical application. In this project, we enhanced the model by simplifying its structure, reducing computational complexity, and streamlining its implementation process. These improvements make the model more accessible and user-friendly, enabling broader adoption in real-world scenarios while maintaining its effectiveness in optimizing ride-sharing operations.

3 Impacts

This project aims to enhance the quality of life for people with disabilities and the elderly by addressing challenges related to social exclusion, accessibility, and mobility while minimizing the effort required to implement complex optimization models in real-world scenarios.

3.1 Impact #1

We have developed the GUI tool with a focus on simplicity, efficiency, and user-friendliness, ensuring that even non-technical users can easily interact with and benefit from its features. Currently, we are actively introducing the tool to the market through various channels, including targeted marketing campaigns, demonstrations, and partnerships with key stakeholders in the

transportation and technology sectors. Our goal is to increase awareness and showcase the tool's practical applications in real-world scenarios, from car-sharing systems to other transportation management solutions. With its intuitive interface and ability to streamline complex optimization tasks, we anticipate a high adoption rate as users recognize its potential to improve operational efficiency, reduce costs, and enhance service delivery.

3.2 Impact #2

Case study results indicate that by achieving an appropriate fulfillment rate, the total ride-sharing fleet size can be reduced by 45.5%, significantly optimizing fleet management. This reduction in fleet size not only leads to more efficient use of resources but also contributes to a substantial 12.9% decrease in total operating costs. The efficiency gains come from minimizing the number of vehicles needed to meet demand while ensuring that service levels remain high, thus lowering costs related to fuel, maintenance, and vehicle depreciation. Additionally, the streamlined fleet reduces the overall environmental impact, aligning with sustainability goals by decreasing emissions and energy consumption. These findings underscore the potential of optimized scheduling and resource allocation to create a more cost-effective and environmentally friendly ride-sharing system, benefiting both operators and users.