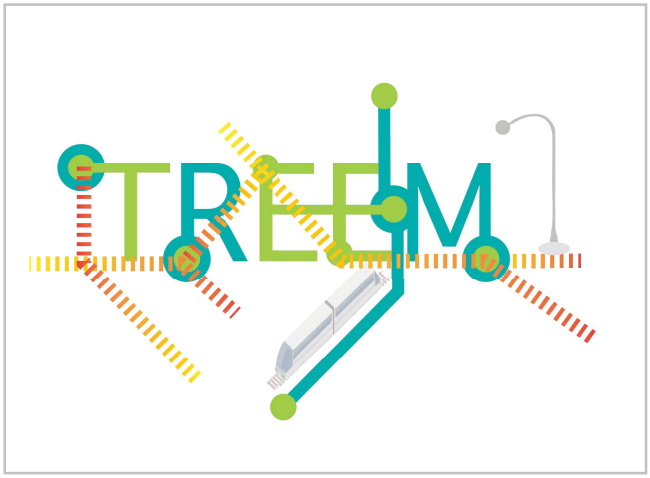
Research Summary

Robust Decision-Making Framework for Sustainable Operations and Planning of MBTA Rapid Transit Vehicles (RDMM)

Research Need

In order to facilitate effective planning for current and future needs, the MBTA requires a framework should also be useful for predicting energy usage in order to evaluate the relevant impacts of proposed strategy decisions, particularly in response to disruptive events or financial constraints. Ultimately, there is a critical need to reduce costs while still meeting the mobility needs of the surrounding communities in the Boston area.



Goals/Objectives

1) Enumerate and analyze high-level operational planning metrics relevant the MBTA decision-making process

2) Train a generative model that provides energy forecasts from the planning metrics

3) Develop a decision-support tool with a user-friendly interface that the MBTA can use to specify planning strategies and compare energy outcomes of various plans

Methodology

1) Pipeline to estimate the distributions of discrepancies between schedule and actual operations for eventual modeling

2) Generate the noise and add to the schedule

3) Estimation of Long Short-Term Memory (LSTM) recurrent neural network to predict daily energy consumption and average daily temperature

4) Implement hypothetical operation plans for a quarterly period to demonstrate the capability of our framework in assessing energy forecasts for various decision-making strategies

Key Findings

Via our research framework, we obtained:
1) A high performance energy forecasting model robust to large disruptions
2) Key planning metrics and a sequence generation approach for modeling specified plans
3) Decision-making framework that generates daily energy forecasts on a quarterly horizon based on specified planning strategies.

The results indicated that the model could reliably predict energy consumption with a root mean squared error (RMSE) of 50.6 MWh and temperature with an RMSE of 6.62°F. The high accuracy and reliability of this model underscore its effectiveness as an assistance of decision-making, providing urban planners and transportation authorities with valuable in -sights to improve energy efficiency and operational resilience in MBTA URT systems.

Through the strategy analysis, the distance reduction strategy appears to have a more pronounced impact on reducing energy consumption, as evidenced by the lower and more variable energy levels compared to the base plan and speed reduction scenario. The temperature predictions are relatively consistent across the different plans with minor variations. This suggests that while the speed and distance reduction strategies significantly affect energy consumption, their impact on temperature predictions is less substantial.

Project Information

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urban rail transit, energy forecasting, LSTM, strategy analysis, decision-making

Use of Findings

We expect our findings (particularly the planning metrics) to be of immediate use to the MBTA in future planning cycles. We also developed a decision-making tool to evaluate the effects of various strategies on energy consumption. Users can simulate various operational scenarios and analyze their impact on energy and temperature predictions by adjusting sliders for different input features such as operating distance, number of trips, and average speed.

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