Michigan Department of Transportation
RESEARCH Administration

RESEARCH SPOTLIGHT

Project Information

REPORT NAME: End-to-End Learning Framework for Transportation Network Equilibrium Modeling

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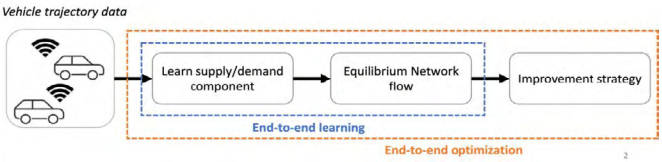
A flexible framework for forecasting travel demand

Transportation planners need up-to-date information on variable travel behaviors and patterns to support decisions on transportation network improvements. A new end-to-end machine learning framework uses vehicle trajectory data to produce continually updated traffic predictions based on actual travel behavior. The forecasting tool supports decision-making for quicker, more effective traffic improvement strategies.

PROBLEM



A machine learning model uses vehicle trajectory data to produce realistic travel behavior predictions and provide decision support for effective transportation network improvements.

To ensure an effective and efficient transportation network for all users, planners at the Michigan Department of Transportation (MDOT) need a thorough understanding of current and future travel demands. Traditional travel demand forecasting considers expected growth and changes in land use, demographics and infrastructure. It requires costly and time-consuming data collection and analysis gathered through household travel surveys to determine travel patterns.

While the household travel survey data and the multistep modeling processes are used for state, regional and local travel planning, travel behavior may change with societal, economic and fast-paced technological changes. When modeling assumptions are outdated, determining the likely effectiveness of potential management strategies for the transportation network becomes challenging.

Advancements in technologies and data collection methods such as radar, Bluetooth and Wi-Fi tracking, mobile device GPS and connected vehicle data are affordable, accurate and flexible tools that can supplement traditional travel demand modeling. MDOT was interested in testing a new framework for estimating travel demand that could provide quicker evaluations of potential targeted highway improvements or policy change scenarios.

RESEARCH

A traditional travel demand modeling process fueled by travel survey data involves four steps: estimating the number of trips in an area, spatially distributing the trips, allocating travel modes and determining trip routes within the network.

Before this project, researchers created a prototype framework based

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"This project showed the potential of revolutionizing travel demand modeling by using vehicle trajectory data and artificial intelligence to create an end-to-end learning framework that reflects realistic conditions and can assess potential improvements."

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on an end-to-end machine learning method to learn travel choice preferences within a network, eliminating the need for intermediate processing steps. The neural network-based framework learns by approximating unknown parameters of a transportation network, adjusting neural network parameters to minimize differences between predictions and the empirical data, and interpreting travel behavior in response to network change.

In this project, researchers evaluated the framework's feasibility through theoretical analysis and tested it using both synthetic and empirical data. Synthetic data mimics real traffic patterns but is created through simulation and used to train models and for other traffic planning functions. Researchers used three widely accepted benchmark network datasets to test various technical aspects of the end-to-end framework.

During a case study conducted in the Ann Arbor area, researchers demonstrated the framework and compared the findings to results from traditional travel demand forecasting. Empirical, crowdsourced data was combined with one year of modeled output from the transportation network in Southeast Michigan Council of Governments' travel demand modeling used for regional forecasting. A General Motors (GM) dataset with vehicle trajectory data from GM cars operating within the study area during evening peak traffic hours enabled machine learning to discover traffic patterns and travel behavior.

RESULTS

Working as an integrated traffic forecasting tool, the end-to-end framework continuously learned and optimized realistic travel behavior predictions. While some link-level traffic patterns can be derived from traffic sensors and cameras, the vehicle trajectory data provides more detailed information about travelers' daily travel and route choices. The passive collection of crowdsourced data allowed for observations during time periods of interest. The approach outperformed the traditional travel demand forecasting method, decreasing prediction errors by more than half and illustrating how factors like weather and weekends affect travel patterns.

Substantially faster and more flexible than traditional travel demand modeling, this approach used existing data sources and automatically learned variations in travel patterns, adjusting predictions accordingly for increased accuracy. As part of the framework's demonstration on the Ann Arbor network, researchers assessed the impacts of potential improvement projects in congested areas. By eliminating the need for extensive data collection and model recalibration, the end-to-end framework, or data-to-decision pipeline, offers promise as a quick and cost-effective traffic planning support tool.

IMPLEMENTATION

MDOT staff recognizes the potential of the new forecasting framework as a flexible and quick planning tool to understand transportation network responses to travel demand. The tool learns based on changing contexts – like weather – reflecting real-world differences and accurately forecasting congestion, travel times and driver behavior.

MDOT will explore supplementing traditional travel demand modeling with the new forecasting tool. Agency efforts to enhance its digital infrastructure will support the needed data management and computing capacities. Additionally, as confidence in and accessibility to third-party data sources grow, the usefulness of tools like the travel forecasting framework will continue to expand.

Research Administration

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The final report is available online at MDOTjboss.state.mi.us/TSSD/tssdResearchAdminDetails.htm?keyword=SPR-1760.

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