Northeastern University
Civil and Environmental Engineering

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Presented by the Department of Civil and Environmental Engineering

Dissertation Defense

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Trouble Ahead, Trouble Behind: Methods for Improving the Headway Regularity of High-Frequency Transit and Lessons from Field Experiments

Abstract: High-frequency transit services are the backbone of mobility systems in multi-modal urban areas. Delivering fast and reliable service on these corridors improves the accessibility of transit-dependent riders and attracts choice riders, which eases congestion and improves environmental sustainability. However, global mobility and economic trends have shifted travel demand and workforce patterns that expose the limitations of existing transit planning practices in meeting the desired levels of service. The operation requires corrective real-time control to respond to delays and uncertainty. Still, theoretical methods do not take into account real-world constraints, and use cases of real-time tools in practice remain limited.

This dissertation fills these gaps by combining large-scale transit data with emerging methodologies to enhance decision-making at the levels of operational planning and control. Specifically, inferential models are used to estimate the effects of operational, urban, and human factors on service reliability at the route and segment levels. As treatments for unreliability, control algorithms for holding and stop-skipping strategies based on reinforcement learning are formulated and optimized for reducing rider journey times. To demonstrate the applicability of the approach in the field, the control models are integrated into a decision support system for operations staff and pilot tested on two high-ridership bus routes. Finally, the control methods are extended to the case of flexible route transit operations to balance ridership and reliability performance.

The methods are tested in a variety of case studies in the Chicago Transit Authority (CTA) and the Boston area. The reliability model insights reveal the various levers that transit planners can use to improve reliability. Simulation experiments indicate that the benefits of control strategies are reduced when accounting for reduced driver compliance; however, it was demonstrated that incorporating this behavior into model training can maximize effectiveness. Furthermore, the deployment of these algorithms in the field resulted in substantial improvements in performance from the perspective of riders, drivers, and agencies, as well as empirical evidence of driver compliance and its factors. When extended to flexible route transit control, the approach also showed effectiveness in increasing the number of requests served and punctuality. Overall, these frameworks and strategies can enable practitioners to increase reliability and add flexibility to the transit operation.

Biography: Joseph Rodriguez is a PhD candidate in the Department of Civil and Environmental Engineering advised by Professor Haris Koutsopoulos and co-advised by Professor Jinhua Zhao. His research relates to the development and implementation of real-time control strategies for high-frequency transit operations. Joseph holds a B.S. in Civil Engineering from the Technion – Israel Institute of Technology and recently joined the data science team at Hayden AI to assess the impacts of their automated bus lane enforcement technology.