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SUMMIT: A MULTI-MODAL AGENT-BASED SIMULATION PLATFORM FOR URBAN TRANSIT SYSTEMS

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ABSTRACT

We present a city-scale transportation simulation platform, named SUMMIT (Singapore Urban Multi-Modal Integrated Transport Simulator), that integrates multiple public transit systems together with a central commuter control. At the core of SUMMIT, a message passing framework called Fabric (Fast, Agent-Based, Reproducible, Integrated Co-simulation) helps synchronize the different transit systems and commuters transiting between them. Using Fabric, each transit system can be implemented independently as a stand-alone simulator, and the central commuter control is responsible for generating the route choice decisions. SUMMIT integrates currently three key public transit modes in Singapore: train, bus and taxi. This holistic simulation platform can be particularly useful for analyzing the complex dynamics in urban transit systems. In an application of SUMMIT, we simulate a hypothetical major train disruption in Singapore. We analyze mitigation scenarios, where bridging buses are deployed, and the impact of information dissemination delay on commuters.

1 INTRODUCTION

Agent-based simulation platforms are important tools that are used extensively today to model the inherently complex interactions present in transportation systems. This study focuses on developing a multi-modal, city scale, agent-based public transport simulator named Singapore Urban Multi-Modal Integrated Transport Simulator (SUMMIT), which is extensively calibrated with real world mobility data sets from Singapore. One important motivation for developing SUMMIT was to create a tool capable of analyzing public transport scenarios. Such tool may help transport operators or planners to be better prepared to manage, for example, train disruption events.

2 SUMMIT SIMULATION PLATFORM

SUMMIT is a multi-modal public transport simulation platform composed of three mode simulators (train, bus, taxi), a commuter control model, and the Fabric integration framework.

In SUMMIT, individual commuters and vehicles are modelled as distinct independent agents. Vehicle agents are simulated by their respective simulators on mode-specific transportation networks. Commuter agents are generated at their origin locations, and proceed through their respective journey plans and interact with each vehicle and each other via events (boarding/pickup, alighting/drop off, transfers, transit, etc.) in simulated time.

A typical SUMMIT scenario involves the simulation of a full day (24 hours) of public transportation service at a full city-wide scale (e.g., entire Singapore bus/train/taxi systems). Real historical data is used to calibrate the journey plans/event parameters to ensure sufficient accuracy of simulation to reality. Buses and trains are generated according to operational schedules, taxis are generated according to full-scale historical spatiotemporal patterns, and commuters are generated according to full-scale travel demand logs. By altering inputs and model parameters, SUMMIT can be used not just to study normal days, but also for scenario modelling and forecasting, such as modelling train disruptions and comparing mitigation strategies for disruption.

SUMMIT is focused on estimating commuter-centric ride experiences on public transportation and parsimoniously models only related phenomena and aspects. But it is not a general purpose road traffic model. Private vehicles (e.g., cars) are not simulated, and vehicles in different modes do not directly interact. Nonetheless, vehicle travel times for each transport mode are calibrated against real-world empirical measurements, and the vehicles still experience congestion within-mode (e.g., bus bunching).

3 SUMMIT APPLICATION: TRAIN SERVICE DISRUPTION ANALYSIS

We study a hypothetical multi-line train disruption scenario, where the train services at three MRT lines are disrupted at multiple stations. Different scenarios for the hypothetical disruption event are simulated by varying the mitigation measures and information availability to commuters. The impact of the service disruption and efficacy of mitigation measures are evaluated using multiple performance indicators like crowd size at the disrupted stations and travel time of affected passengers.

The results from the scenario simulations show that, bridging bus services, which is one of the most commonly used mitigation measure is able to reduce the crowd size at the MRT stations. But, the travel time of commuters are increased with bridging bus scenarios compared to no bridging bus scenarios. This is due to the large number of commuters shifting to bridging bus routes from alternative MRT routes in the mitigation scenario, resulting in higher bus waiting time and overall travel time, which is a direct consequence of huge difference in throughput of a train route compared a bus route. All performance indicators were found to be better when the information on disruption is disseminated to commuters without any delay.

4 CONCLUSIONS

This study presented a multi-modal agent-based public transport simulator named SUMMIT with an application in public transport contingency planning that was demonstrated by simulating a major unplanned train service disruption in Singapore. Scenario simulations show that mitigation measures like bridging bus services are able to reduce the crowd size at MRT stations, but not the travel time of affected commuters. At the same time, there is a considerable reduction in both the crowd size at the MRT stations and travel time of affected commuters if the information about the service disruption is passed on to the commuters instantly.

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