Smart Cities, Mobility services, Disaster preparedness & urban planning

LLM-based urban transportation simulation framework

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Abstract

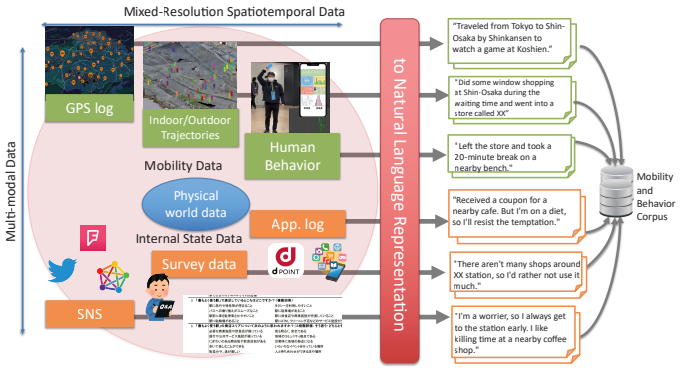
Rapid aging, disaster resilience, and congestion demand a step change in urban transport. Real-world trials are costly and risky, so data-grounded simulation is essential. Conventional models replicate past patterns and miss intentions, thus fail under sparse, novel conditions. We propose a framework that uses large language models (LLMs) as simulation agents. Mobility data (GPS, timetables) and motivational data (social media, surveys) are normalized into natural language and learned jointly. This enables agents that embed human-like decision making and respond plausibly to counterfactuals and disruptions. By allowing scenarios to be specified in ordinary language, the framework lowers the barrier for stakeholders to test “what-if” cases and compare policies. The result is a robust, interpretable next-generation urban transportation simulation platform.

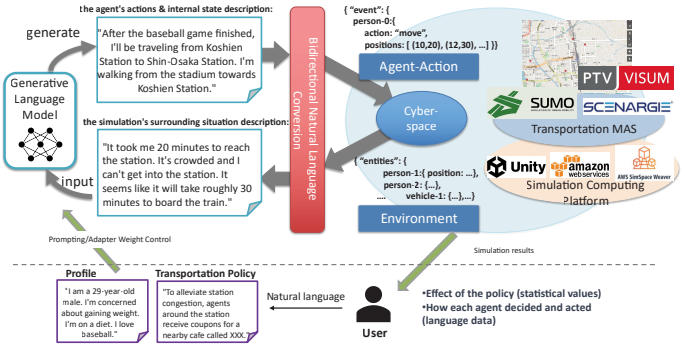
Background & Results

Urban mobility faces multiple challenges: decarbonization, sustaining services in aging regions, disaster resilience, and congestion. On-site experiments are constrained by cost and safety, making digital twins and simulation essential. Yet movements are driven by purposes and intentions, while conventional methods learn surface patterns and generalize poorly to novel settings. Data are heterogeneous in scale and format, from GPS big data and indoor dwell times to social media and questionnaires, with no common representation. Although deep-learning agent models are emerging, they are often opaque, hindering validation and policy uptake. Our approach leverages LLMs, typified by ChatGPT, as simulation agents. We normalize mobility histories, facility attributes, time and weather contexts, and motivational texts into natural language, and integrate them using the connective and generative abilities of LLMs. We design multi-scale coupling from city networks to building interiors and enable robust inference under missing or variable quality data. This lets users specify counterfactual rules or disruptions in plain language and obtain policy comparisons, sensitivity analyses, and bottleneck detection. Our “Agent-Navigation” technique allows the language model to perceive the simulated environment and generate or update action plans in text according to constraints and objectives, exposing its reasoning for audit and consensus building. In a regional tourist area, evaluating the agent as a next Point-of-Interest (POI) predictor across diverse personas achieved 49.1% accuracy. We will next validate three scenarios: congestion mitigation for large events, impact of new mobility services, and evacuation guidance, moving toward operational deployment.

Significance of the research and Future perspective

Because agents can verbalize their decision process, the platform supports validation and shared understanding among stakeholders. Non-experts can describe conditions such as “if a tsunami blocks this road” or “increase frequency on this line” and immediately examine network responses, including rerouting and demand shifts. Looking ahead, we will extend the system into an “Urban-space AI Service” that automatically explores the policy space for demand forecasting, service planning, and evacuation strategies, presenting both effects and side effects. By integrating open datasets and existing simulators, we aim to deliver a practical platform embedded in the daily operations of municipalities and transport operators.





Patent	
Treatise	Yasuda, Yu; Amano, Tatsuya; Yamaguchi, Hirozumi. A digital twin approach for crowd flow modeling on railway station platforms. 2025 IEEE International Conference on Smart Computing (SMARTCOMP). 2025, 82–89. doi: 10.1109/SMARTCOMP65954.2025.00069 Uegaki, Masashi; Amano, Tatsuya; Yamaguchi, Hirozumi. Simulating urban pedestrian flows by fusing wide-area location data and spot pedestrian counts. EAI MobiQuitous 2024 - 21st EAI International Conference on Mobile and Ubiquitous Systems: Computing, Networking and Services. 2024. doi: 10.1007/978-3-032-10554-7_29
URL	https://mc.net.ist.osaka-u.ac.jp/en/
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