Transferring Urban Mobility Between Cities: A Data-Driven Synthesis Framework

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1 Introduction

Large-scale human mobility data provide a rich foundation for studying urban dynamics, transportation demand, and behavioral regularities. Yet real mobility traces are extremely difficult to obtain due to privacy constraints and the prohibitive cost of large-scale sensing. Even when datasets exist, they are geographically limited and rarely shareable across institutions. This leaves a critical gap between the need for realistic mobility data and the ability to analyze or simulate it. To bridge this gap, we aim to generate **synthetic but realistic mobility trajectories** that preserve the statistical and behavioral structure of real individuals while eliminating personally identifiable information.

Existing data-driven simulators either rely on coarse statistical assumptions such as gravity or radiation models, or sample locations uniformly from population grids, often producing trajectories that violate spatial semantics; for example, individuals commute through parks, stop in areas without relevant land use, or traverse disconnected road segments. Moreover, most models are tightly coupled to a single city, failing to generalize to new geographies. The research challenge is to synthesize trajectories that are (i) behaviorally faithful to observed human activity patterns, (ii) spatially consistent with a target city's infrastructure and land use, and (iii) tunable in their level of randomness to support privacy-utility trade-offs.

2 Our Approach

We propose IMN Cloning, a framework that generates activity-aware synthetic mobility trajectories by decoupling temporal and spatial learning. The process begins with publicly available datasets of individual-level trajectories, such as the *Milan 2007* or NetMob25 [2] mobility datasets, from which we learn behavioral patterns that characterize real urban movement. In the temporal stage, we extract mobility rhythms by modeling each user's Individual Mobility Network (IMN) [1] as a sequence of stays annotated with activity labels such as home, work, eat, or school. The behavioral model captures both regular routines and exploratory tendencies, enabling realistic synthetic mobility generation in any target city by embedding observed human behavior into new spatial contexts.

In the spatial stage, temporal behaviors are mapped onto the target city using fine-grained OpenStreetMap data. Candidate locations are drawn near relevant amenities and weighted by population density to ensure geographic and functional realism. Synthetic trajectories are then constructed by connecting these locations through shortest-path routing on the road network, producing temporally aligned and spatially plausible mobility traces.

Ongoing work focuses on quantitatively validating the generated trajectories through trip-length and duration distributions, origin–destination matrices, and temporal activity profiles, to ensure alignment with empirical mobility laws. We plan to release the complete pipeline as an open, easy-to-use research tool that enables urban scientists, transportation engineers, and data-management researchers to generate realistic synthetic mobility data for any target city without requiring access to sensitive individual trajectories.

References

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