

The Privacy-Utility Trade-off in Spatial Aggregation: An Evaluation Framework for Origin-Destination Flow Visualization

Suphaphong Sirinapaphan ^{a,*}, Anna Elke Brauer ^a

^a Technische Universität Dresden (TUD)

* Corresponding author: suphaphong.si@gmail.com

Keywords: spatial aggregation, geomasking, human mobility, privacy-utility trade-off, origin-destination data, flow visualization

Abstract:

Mobility data, including origin-destination (OD) pairs, offers valuable insights for urban planning and transportation (Mokbel et al., 2023). However, sharing such data raises significant privacy concerns, as individual movement patterns may be re-identified even from pseudonymized datasets. Spatial aggregation, a geomasking technique that groups individual data points into discrete geometric units (Wang, 2024), provides a visually interpretable approach to privacy protection. Despite its widespread use, no study has systematically compared how spatial aggregation methods influence both privacy protection and data utility in the context of mobility OD data.

To address this gap, this study aims to introduce a privacy-utility trade-off evaluation framework for spatial aggregation methods in OD flow visualization. The framework will operationalize spatial k-anonymity to define privacy metrics and will employ a suite of utility metrics to quantify information loss introduced by each aggregation configuration. A systematic trade-off analysis will determine which methods and resolution levels achieve the most favorable balance between privacy protection and data utility for a specific use case. The applicability of the framework will be demonstrated using the Bangkok taxi trajectory dataset, published as open data by the iTIC Foundation (iTIC Foundation, n.d.). The iTIC foundation is a Thai non-profit organization that collects and processes traffic data in Thailand.

To support communication, a web-based interactive visual interface will be developed to enable analysts and decision-makers to explore aggregated OD flow patterns and compare privacy-utility outcomes across spatial aggregation methods and configurations. The study's results are expected to show how the tension between privacy and utility manifests in the case of aggregated OD flows, with the evaluation framework and the decision-supporting interface being transferable across datasets and study areas.

References

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