A Comprehensive Study on Bike Sharing Mobility in the City of Munich: Utilizing Community Detection Method

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Bike-sharing systems have emerged as a transformative solution to urban transportation challenges, particularly addressing the first and last-mile problems [1]. They offer a sustainable and eco-friendly public transit mode while providing users with cardiovascular benefits [2]. Beyond reducing travel costs and durations, bike-sharing systems operate as dynamic networks with nodes representing spatial units and edges signifying traffic flows between them. However, interpreting the complex spatial patterns of human mobility within these networks presents a significant challenge in graph theory [3]. Therefore, community detection methods are vital in uncovering clusters and modules within bike-sharing mobility data, revealing complex spatial patterns, and enhancing our understanding of urban transportation dynamics.

Objectives

The main onjevtive of this study is to develop a spatiotemporal analysis workflow to model dynamic community structures of bike share usage.

Methodology

The methodology comprised four main stages presented in Fig. 1:

1. Data Preparation & Static Community Detection on Snapshots

2. Community Membership Graph Generation

3. Consensus Community Detection & Dynamic Sub-Community Detection

4. Dynamic Sub-Community Graph Generation.

The mobility data is collected from official website of Munich's public transporta tion company "MVG Rad" and includes origin - destination information of each bicycle trip happened in 2022 [4].

Case Study & Results

To detect static communities, we constructed graphs with nodes representing spatial units and edges representing traffic flows between districts. The edge weights were determined by counting the number of bicycle trips between district pairs. First we have divided our mobility trip data into 2 hour intervals and applied infomap algorithm to get static communities on each snapshot. As seen in Fig. 2.a, static communities have complex structure and neglecting dynamic nature of the human mobility.By utilizing consensus clustering technique we have generated both spatially & temporally, strongly connected consensus communities. In Fig 2.b we can conclude that consensus community borders are showing parallelity with physical bariers such as train lines, highways, and parks. On the last step, we have divided our mobility data 48 time intervals, and utilized consensus communities to reveal daily rythm of human mobility. In Fig. 2.c, we can see that our proposed framework is robust to temporal changings and can reveal daily human mobility by representing connecting regions within the study area. The given example illustrates the increase in the number of connected regions between 06:00 - 08:00 in the morning.

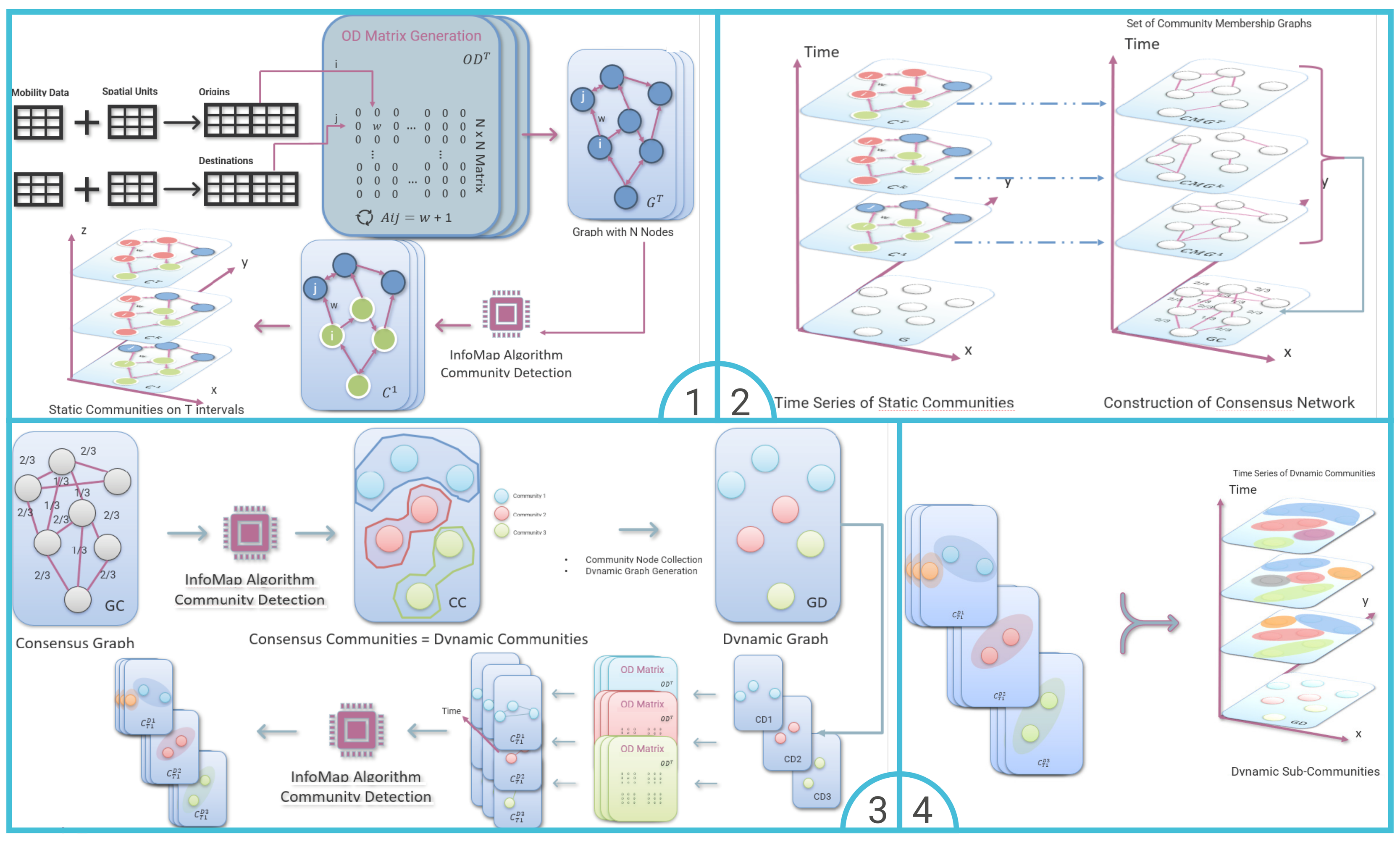

Fig. 1 Proposed workflow to detect dynamic communities of human mobility.

Conclusion

This research has provided a robust methodology for the analysis of bike-sharing communities, considering both spatial and temporal aspects. By applying dynamic community detection to mobility data, we can better understand how these communities evolve throughout the day and gain valuable insights into urban mobility patterns. Overall, the study contributes to the fields of Geographic Information Science, Cartography, and Urban Transport Planning by offering a systematic approach to analyzing human mobility patterns within bike-sharing systems, with a focus on dynamic community structures.

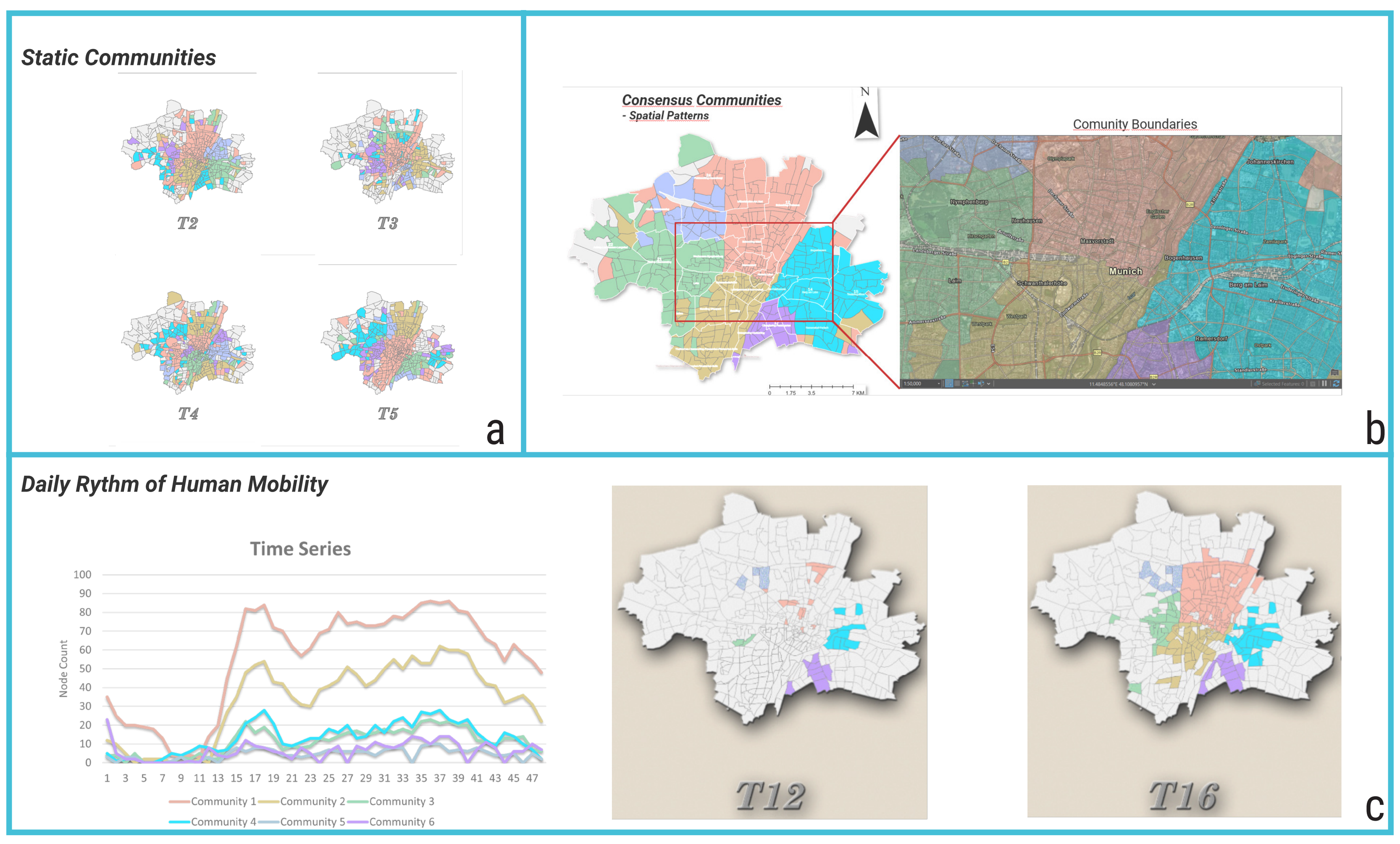

Fig. 2 Resulting Communities of proposed workflow. The figure represents (a) Static communities, (b) spatially & temporally connected consensus communities, and (c) dynamic subcommunities and daily rythms of human moblity.

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