Mobility Preferences Analysis Based on Travel Mode Activities and Patterns

Lijuan Zhang[1], Ayelet Gal-Tzur[2], Sagi Dalyot[1]

The mobility of people in space has drawn lots of attention in the social, geographical and transportation sciences. Human mobility plays a significant role in exploring the size and structure of urban areas, the spatial distribution of facilities and efficiency of transportation services. With a growing demand for mobility in urban areas, city and transportation planners are facing critical challenges. A thorough understanding of travelers' mobility preferences and patterns is crucial for efficient planning of land use along with transport infrastructure and services.

When planning trips, travelers take into account the available travel modes and network characteristics, and base their choices on the available alternatives. Until recently, information regarding travelers' preferences was based on analyses of questionnaires and manual surveys, i.e., stated preferences. Thanks to the development of new technologies, especially location-based data, information about people interacting with the environment are dramatically increasing. Drawing knowledge from these data sources and analyzing travelers' travel activities can help us investigate the preferences and limitations of the urban infrastructure with the aim to improve transportation and city planning.

Urban infrastructure and facilities allow people to travel from one location to another by one or more travel modes, e.g., walk, bicycle, car and public transportation. In this work, we present a set of algorithms, based on location-based data, for analyzing journeys in terms of travel modes and routes, as well as relationships between travel patterns, the urban network and spatial characteristics. Such analysis is most valuable for urban and transportation planning as it provides insights on matters such as the preferable travel modes between locations and acceptable walking distances to the nearest bus station.

The analysis is divided into stages, as follows:

1. Pattern matching – Since GPS location errors occur (mostly within a range of less than 10 meters), a map matching algorithm is implemented to geometrically align the actual travel route, which is presented as a GPS trajectory with route location points on a transportation network that stores the various road types (e.g., paths, sidewalks, ways). This helps analysts identify the actual segments of an entire journey.

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[1] Faculty of Civil and Environmental Engineering, The Technion, Israel
[2] Transportation Research Institute, Technion and Ruppin Academic Center, Israel

2. Travel mode classification – A hierarchical classification process that uses Fuzzy Logic and Support Vector Machine algorithms is implemented on each GPS trajectory to automatically identify the route and composition of the selected travel modes. These are based on defined travel and movement pattern parameters (velocity, heading change, stops, et al), including verification rules expressing logical travel patterns that are designed to avoid incorrect classification. Thus, on the basis of travel locations (GPS points) and knowledge of origin and destination, we can retrieve the used travel modes and spatial patterns.

3. Cluster formation - investigating the heterogeneity of spatial distribution of travel modes based interactions, we implement a complex network analysis method to identify clusters of specific travel modes based interactions (links). Nearest-Neighbor analysis is applied to assign the origins and destinations of trips to their nearest neighborhoods. Origins and destinations of trips are then used to build a travel mode-based spatial interaction network. In this origin-destination network, a node represents a neighborhood and an edge represents an interaction between two neighborhoods with a specific travel mode. The edges are given a weight measured by the number of trips taken between interacted pairwise nodes using a specific travel mode.

4. Community identification - the origin-destination grid is a complex network in which links are not evenly distributed among nodes. The nodes of a complex network can be divided into groups: sub-network, with internal dense connections; and sparse external connections between groups, which are considered here as communities. The community-based approach is widely used to analyze the structure of complex networks. In this study, we have used the Walktrap algorithm (Pons and Latapy, 2005), a hierarchical clustering algorithm iteratively merging nodes into communities, to divide the network into sub-networks, i.e. clusters of spatial interactions. The communities are understood to comprise a relatively large number of nodes and intra-community links (trips).

We make our analysis using a travel dataset compiled in Tel-Aviv, Israel. Sixty-three participants were recruited for a three-month study. The commuters were asked to plan their route using the AlterNativ application for their trips. Based on alternatives travel plans generated by the AlterNativ application, commuters are asked to choose their preferred travel mode and route (their stated preferences), which are logged into the system. In addition, the actual journeys taken (revealed preferences) are analyzed on the basis of our pattern matching and travel mode classification algorithms. Clearly, a sample of sixty-three individuals is not sufficient to draw conclusions regarding travel patterns in Tel Aviv. However, our work provides proof of concept for the developed algorithms. Figure 1 depicts an example of stages 1 and 2, demonstrating the feasibility of identifying gaps between stated and revealed preferences. In Figures 2 and 3, specific communities with large differences in size and spatial extent are identified for different travel modes. The results, based on users' selections reported via the AlterNativ application, demonstrate our ability to analyze human mobility with regard to travel modes and spatial dispersion. The results of the analysis process can be further explored by integrating the functions of land use patterns in neighborhoods covered by the noticeable travel clusters. Thus, we conclude that the analysis process presented in our quantitative survey of human mobility in urban areas can provide valuable information for transportation and urban planning.

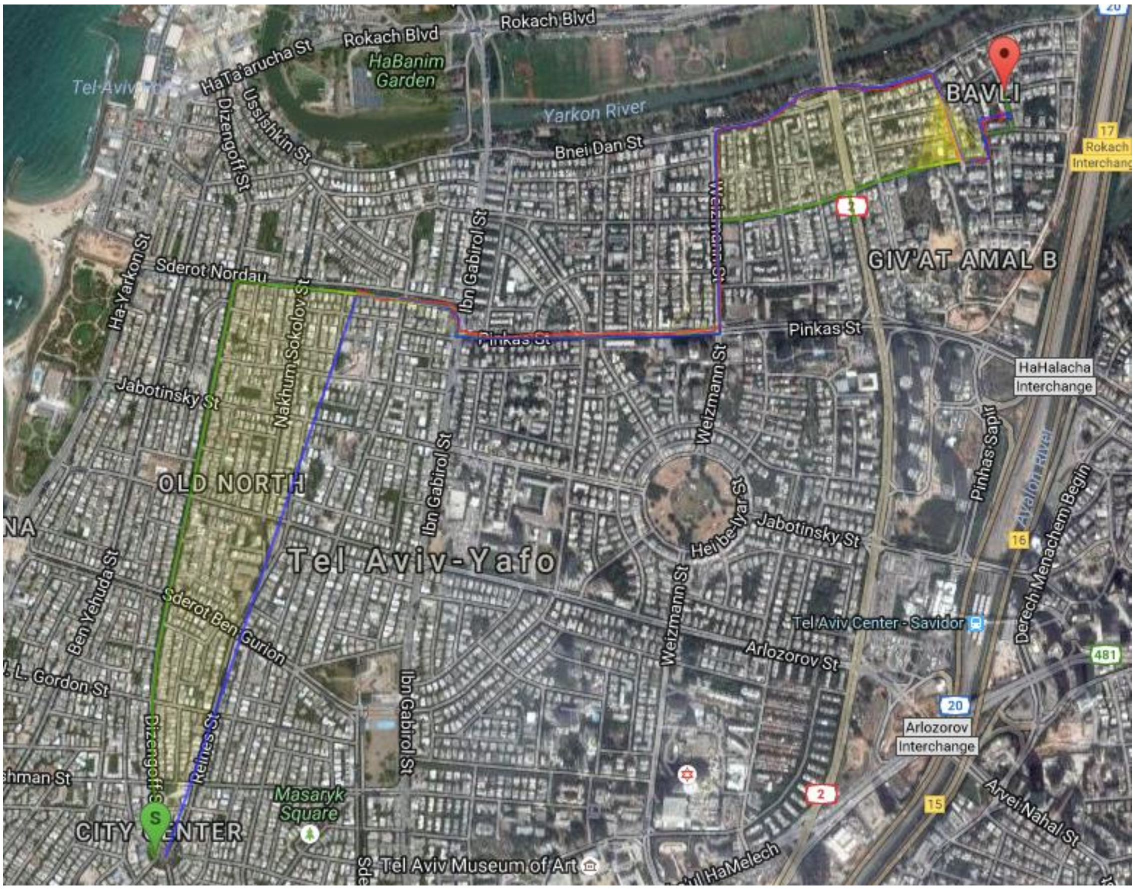

Figure 1. The stated route (green), revealed trajectory (red) and map matching result (blue). The light green areas depict journey deviations. The stated travel mode is bus, whereas the route was traveled by car.

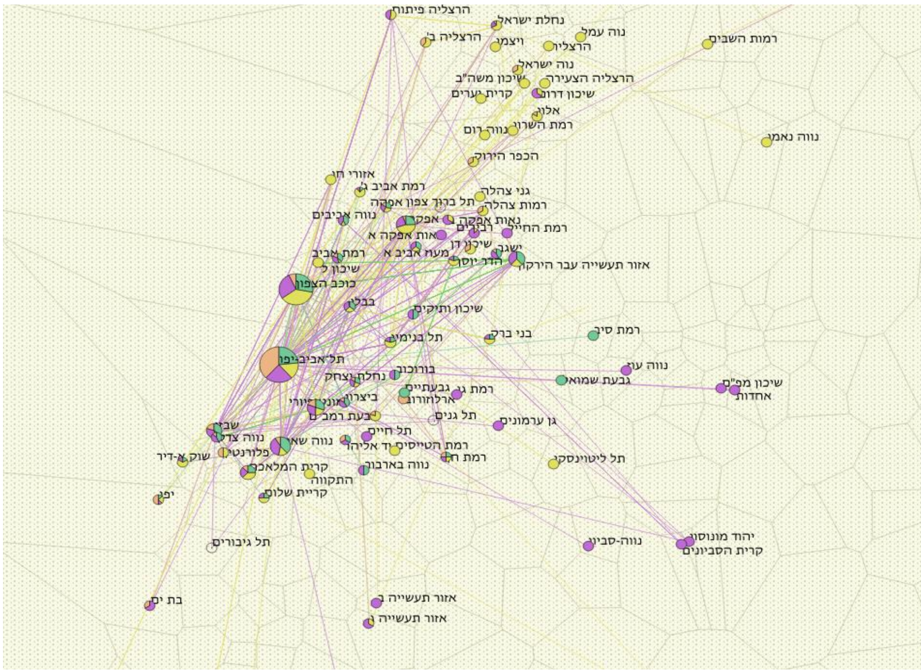

Figure 2. The origin-destination network of four travel modes. The amount of trips at each node is depicted by the size of nodes (pie chart), illustrating the components in terms of travel modes: walk (brown), bicycle (green), bus (purple) and car (yellow). Trips between nodes are shown as lines with different colors, accordingly.

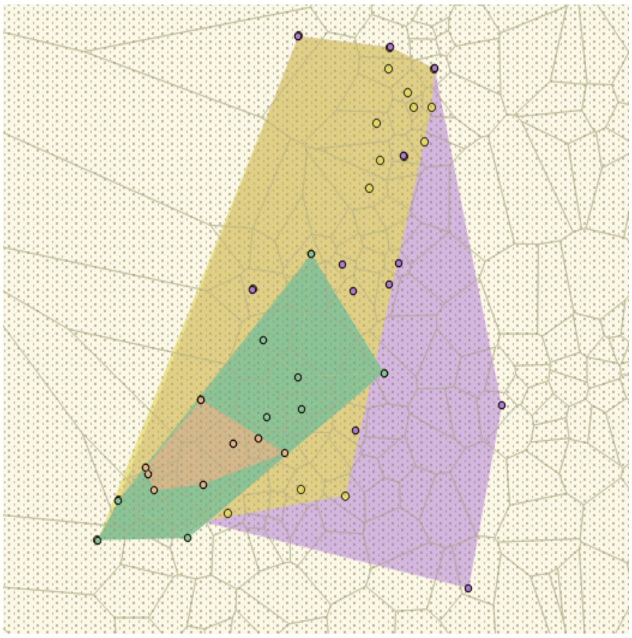

Figure 3. Four explicit communities detected on the basis of travel modes: walk (brown), bicycle (green), bus (purple) and car (yellow).

Pons, P. and Latapy, M., 2005. Computing communities in large networks using random walks. International Symposium on Computer and Information Sciences (pp. 284-293). Springer Berlin Heidelberg.