Barriers of Urban Mobility

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Urban barriers are obstacles of social interactions and even the built urban infrastructure, which is aimed to facilitate access, can hinder mobility. Major roads, for example, are built to increase accessibility. Yet, roads connecting distant places can be obstacles to local community that has been widely recognized [1]. In this paper, we examine how urban barrier affect different kinds of individuals.

We use GPS-based mobility data was used between 2019 September and 2020 February in Budapest provided by a data aggregator company that collects and combines anonymous location data from smartphone applications. The mobile positions were then clustered into stops, using the Infostop algorithm [2], where a user spent some time during the day. Then, the stops were mapped to block polygons, extracted from OpenStreetMap. Two blocks are connected by an edge if a user had consecutive stops between the given blocks within a day. Then, a community detection algorithm to characterize the spatial structure of mobility networks [3, 4], we apply the Louvain method to the stop-network with different resolution parameters (γ) that clusters the blocks into communities [5].

Next, we define the Barrier Crossing Ratio (BCR), BCR_γ, that depends on the resolution, measures the relationship between those mobility events that cross barriers and those that cross barriers and detected communities as well (Figure 1c). We calculate the fraction of barrier and community crosses among all barrier crossings, and then take the inverse of this ratio. Since barrier crossings are constant, a decreasing value of the indicator along increasing resolution signals that border crossings align with community crossings.

We use the mobility network across Budapest blocks to quantify the tendency that individual mobility events cross urban barriers and detected urban communities in the mobility. Although mobility considered only within Budapest, inhabitants of the agglomeration are distinguished. The home location estimation in this data was introduced in a previous work [6].

The detected communities on the mobility network tend to fit administrative (Figure 1a) and physical barriers (Figure 1b). However, administrative barriers dominate in one area (Figure 1b/marker 1) and physical barriers matter more in another area (Figure 1a/marker 2). District 21 (Figure 1b/marker 3) is a special case as it is location on an island thus the physical and the administrative barrier match, and its community remains stable across the different γ values.

We find a striking difference between the BCR indicator of those dwellers who live in the city and those who live in its agglomeration. Figure 1d shows the districts groups of Budapest by purple colors and the six sectors of the agglomeration by green colors. In every barrier category, the agglomeration sectors have higher BCR values than sectors of the city (Figure 1e, 1g, 1f and 1h), indicating that commuters from the agglomeration cross relatively more urban barriers without crossing community boundaries than residents of city sectors do. This indicates that the number of total urban barrier crossings is higher than those crossings that are across barriers and communities at the same time. Increasing γ provides a better fit of network communities to urban barriers, in which the differences between urban and agglomeration sectors are stable as γ grows.

Our results demonstrate that physical and administrative boundaries can separate individuals as well. We show that urban barriers better align with mobility clusters of urban dwellers and less so for residents who live in the larger metropolitan area and commute to the city. These results contribute to the ongoing discourse on urban segregation, emphasizing the importance of barriers to urban mobility in shaping neighborhood interactions and mixing.

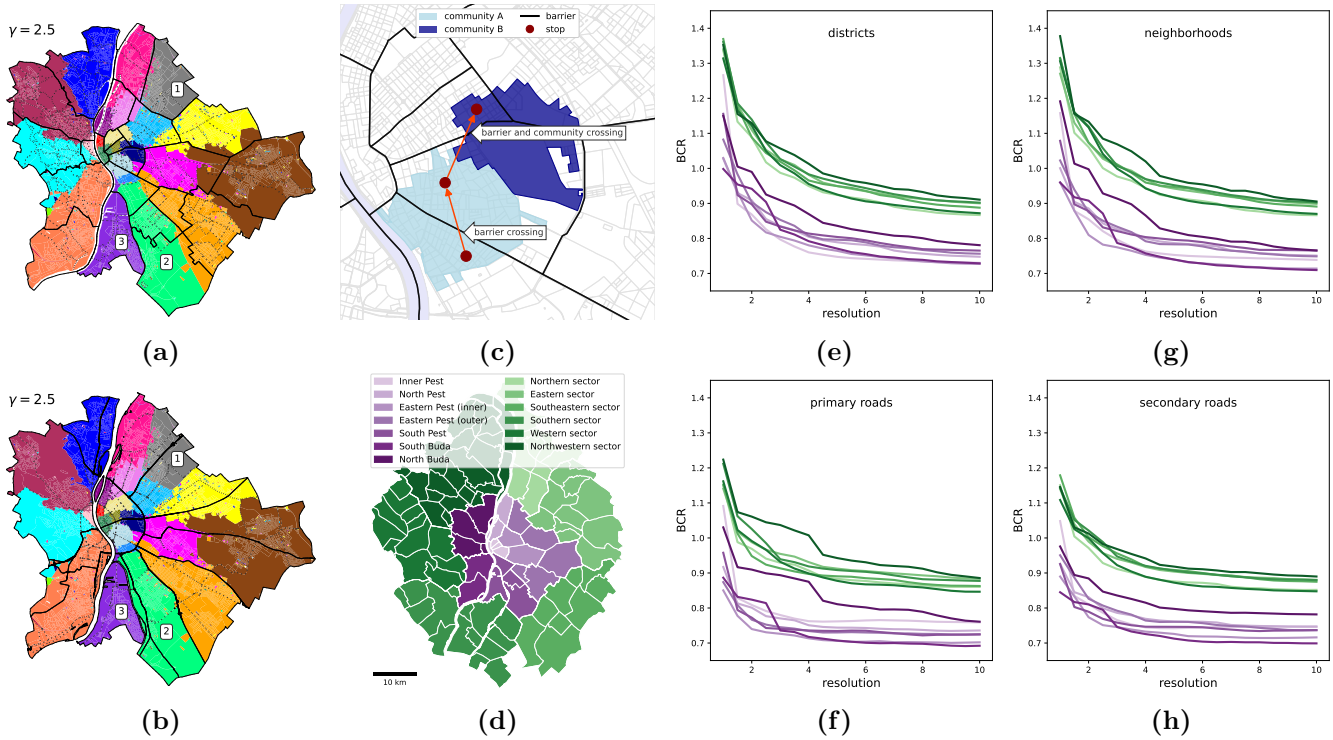

Figure 1: The Louvain communities of resolution 2.5 compared to administrative boundaries (**a**) and the major roads (**b**), the concept of barrier and community crossing (**c**), Budapest (purple) in contrast to its agglomeration (**d**), and the barrier crossing ratio (BCR) by barrier type based on the resolution of the community detection and the individuals' area of residence (**e**, **g**, **f**, **h**).

References

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