

Leveraging OpenStreetMap to investigate urban accessibility and safety of visually impaired pedestrians

Achituv Cohen¹, Asya Natapov² and Sagi Dalyot^{3,*}

¹ Department of Geography, University of California, Santa Barbara, USA; achituvcohen@ucsb.edu

² School of Architecture, Building and Civil Engineering, Loughborough University, UK; a.natapov@lboro.ac.uk

³ Mapping and Geoinformation Engineering, The Technion, Haifa, Israel; dalyot@technion.ac.il

* Author to whom correspondence should be addressed.

This abstract was accepted to the Academic Track of the State of the Map 2022 Conference after peer-review.

Many efforts that include city policy and planning strategies are implemented to encourage urban active mobility. The outcome of these actions is measured by how transportable and accessible the city is. Although contribution is evident, in practice, the commonly used measures mostly disregard a huge part of the population that have mobility impairments requiring specific accessibility needs and preventing them to be an equal part of the sustainable city vision [1,2].

This research suggests using OpenStreetMap (OSM) data in customized analytical models to assess the accessibility level of the urban environment for visually impaired pedestrians. The models analyze the city on two levels: routing and accessibility. These are evaluated, correspondingly, based on possible routes, e.g., how long the optimal route is for visually impaired pedestrians compared to the shortest one, and on area, e.g., what is the overall accessibility and safety of a predefined urban extent. The play of both measures enables us to quantify the level of mobility and accessibility of the analyzed city.

To do so, we implement the following steps:

1. We examine the navigation preferences of visually impaired pedestrians in the urban space. This allows a better understanding of the various environmental and morphological factors and characteristics of the urban form that promote safe and accessible navigation [3,4]. These are translated into spatial and temporal criterion: a) Way Type, which quantifies how suitable the path is in terms of usage and safety; b) the existence of Vision Impairment Assistive Landmarks that support safe wayfinding and navigation; c) Way Complexity, which measures the level of linearity of the path; and d) Crowdedness, which measures the overall pedestrian traffic volume.
2. We transform OSM's street network into a weighted graph, where for each graph edge we calculate the cost according to the above criteria. Cost is derived from

Cohen, A., Natapov, A., & Dalyot, S. (2022). Leveraging OpenStreetMap to investigate urban accessibility and safety of visually impaired pedestrians.

In: Minghini, M., Liu, P., Li, H., Grinberger, A.Y., & Juhász, L. (Eds.). Proceedings of the Academic Track at State of the Map 2022, Florence, Italy, 19-21 August 2022. Available at <https://zenodo.org/communities/sotm-22>

DOI: [10.5281/zenodo.7004666](https://doi.org/10.5281/zenodo.7004666)



segments (and OSM points and polygons nearby) that facilitate safe and accessible walking for visually impaired pedestrians (e.g., separated sidewalks and straight paths), and segments that hinder safe and accessible walking for visually impaired pedestrians (e.g., shared and overcrowded streets).

3. We develop three analytical models that measure the accessibility level of the urban environment for visually impaired pedestrians: a) street-based, which relies on averaging the costs of all graph edges for a given area, hence it can be implemented for different urban levels (spatial extents); b) centrality-based, which adds on the street-based the centrality indices betweenness and closeness [5] that consider the significance of each graph edge in the street network in respect to all other edges (high centrality values mostly signify streets that attract large pedestrian traffic flow); c) route-oriented method, in which numerous routes are generated on the graph for location tuples, defined by graph vertices, and then the ratio of the optimal route for visually impaired pedestrians and the shortest route (commonly used for seeing pedestrians) is evaluated. The smaller the ratio value, the more accessible the route.

The developed models are evaluated for Greater London, the UK. 33 boroughs with their wards are analyzed, resulting in processing 421,107 streets, 377,164 OSM nodes and 634,871 OSM ways. Results show the existence and spatial distribution of accessibility problems for visually impaired pedestrians. The street-based model, depicted in Figure 1, highlights the fact that in some urban areas, nature and green spaces, which are typically considered as contributing to wellbeing and encourage walking, are less accessible for visually impaired people, mostly due to the existing road types, e.g., gravel and dirt roads or shared spaces (bikes and pedestrians that share the same path), which are less accessible for this population. The centrality-based model shows that central streets are mostly more accessible, meaning that borough centers and connected streets are considered in general as accessible.

The route-based model, where more than 1,500,000 routes (with length shorter than 1,000 meters) were calculated, showed that on average the optimized routes are 11% longer and 17.5% more accessible than the shortest ones. Some optimal walking routes are twice as long as the shortest ones, where some impose safety issues that critically endanger visually impaired pedestrians. Wards that have a large proportion of street segments with poor accessibility evenly distributed throughout the ward tend to show less efficient route planning in terms of optimal routes that are considerably longer. In general, the route-based model produces clearer results to understanding the city's morphology in terms of accessibility for visually impaired pedestrians.

To a large extent, these models depend on the quality of OSM data, such as feature completeness and tag correctness. In terms of completeness, we found that sidewalks and crossings, which are two important model features, are not always mapped in OSM, mostly in the outskirts of London. One solution is to use learning methods and prediction models to complete missing data. In terms of tag correctness, we found that some inconsistencies exist with certain tags. One solution can be to make tag definitions in, e.g., OSM Wiki, more inclusive and clear, with a focus on accessibility aspects.

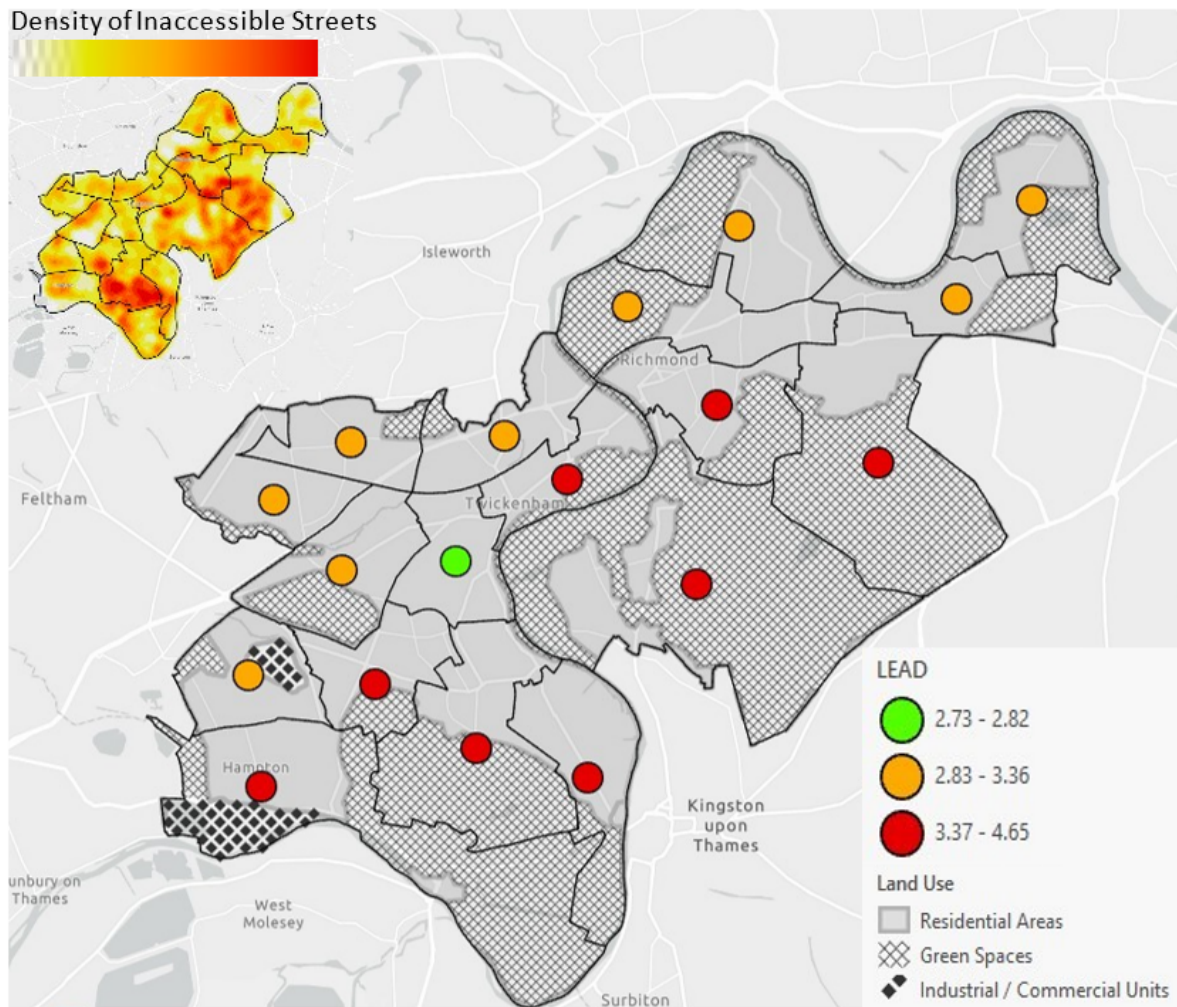


Figure 1. Richmond upon Thames spatial extent and its wards' boundaries (black polygons). The spatial distribution of land uses, and wards' LEAD values (denoted by colored circles). Top Left - Heat map of inaccessible street segments (in red).

Results of this study show how various accessibility levels for visually impaired pedestrians might be assessed and where they are found in the city, pointing to the existing problems this community faces when navigating. These include challenging street network connectivity and dangerous walking areas. Based on this work, the urban accessibility for other impaired communities can be considered while adjusting the navigation preferences and criterion used in the developed analytical models. Moreover, a more fine resolution of accessibility can also be considered, e.g., accessibility to shops and buildings.

The results demonstrate that the current practice of urban planning and design worldwide still suffers from lack of democratization, limiting the mobility and navigation of certain groups. The accessibility models developed in this research can be used for better city planning and design, enhancing the city mobility and walkability equality and improving quality of life for these vulnerable road users. Our findings provide analytical tools to enable decision makers, city stakeholders and practitioners to enrich management, monitoring and development of their cities, and support sustainable, livable lifestyles and walkability equality. These, in turn, will ease navigation and mobility of visually impaired pedestrians, overall improving health outcomes and their integration into society.

References

- [1] Campisi, T., Ignaccolo, M., Inturri, G., Tesoriere, G., & Torrisi, V. (2021). Evaluation of walkability and mobility requirements of visually impaired people in urban spaces. *Research in Transportation Business & Management*, 40, 100592.
- [2] Kocaman, S., & Ozdemir, N. (2020). Improvement of disability rights via Geographic Information Science. *Sustainability*, 12(14), 5807.
- [3] Cohen, A., & Dalyot, S. (2021). Route planning for blind pedestrians using OpenStreetMap. *Environment and Planning B: Urban Analytics and City Science*, 48(6), 1511–1526.
- [4] Cohen, A., & Dalyot, S. (2020). Machine-learning prediction models for pedestrian traffic flow levels: Towards optimizing walking routes for blind pedestrians. *Transactions in GIS*, 24(5), 1264–1279.
- [5] Cooper, C.H.V. (2015). Spatial localization of closeness and betweenness measures: a self-contradictory but useful form of network analysis. *International Journal of Geographical Information Science*, 29(8), 1293–1309.