Interactively Modeling and Visualizing Neighborhood Accessibility at Scale: An Initial Study of Washington DC

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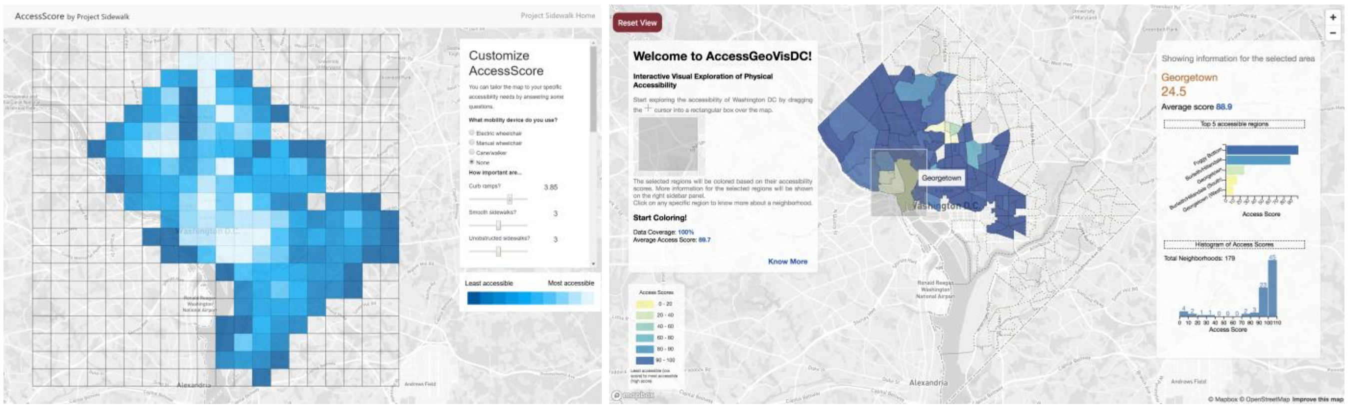

Figure 1. In this poster paper, we explore the initial design and implementation of two interactive geo-visualizations of neighborhood accessibility for people with mobility impairments: **(a)** *AccessScore* and **(b)** *AccessVisDC*. Both prototypes model and visualize accessibility using Project Sidewalk's API [9].

ABSTRACT

Walkability indices such as walkscore.com model the proximity and density of walkable destinations within a neighborhood. While these metrics have gained widespread use (*e.g.*, incorporated into real-estate tools), they do not integrate accessibility-related features such as sidewalk conditions or curb ramps—thereby excluding a significant portion of the population. In this poster paper, we explore the initial design and implementation of neighborhood accessibility models and visualizations for people with mobility impairments. We are able to overcome previous data availability challenges by using the Project Sidewalk API, which provides access to 255,000+ labels about the accessibility and location of DC sidewalks.

Author Keywords

Urban accessibility; geo-visualization; walkability indices

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI)

INTRODUCTION

Websites such as walkscore.com model and visualize the "walkability" of neighborhoods by measuring the proximity and density of walkable destinations (*e.g.*, grocery stores, parks, and restaurants). While recent work suggests that neighborhood walkability correlates with real estate value, lower crime rates, and more walking trips for non-work purposes [3, 7], these metrics do not incorporate accessibility-related features such as sidewalk conditions, the presence of curb ramps, and road grade. One key challenge has been data availability.

Enabled by *Project Sidewalk's* API (projectsidewalk.io/api), which provides access to 255,000+ labels describing the accessibility and location of Washington DC sidewalks [9], we designed and implemented two interactive geo-visualizations of neighborhood accessibility for people with mobility impairments (Figure 1). While recent work has explored accessibility-aware pedestrian routing algorithms and tools [1, 11], these systems are focused on *wayfinding* rather than modeling and visualizing higher-level abstractions of accessibility. Our aim is complementary: to provide personalizable, interactive, and glanceable visualizations of city-wide accessibility.

As early work, our research questions are exploratory: how can we develop algorithmic models that accurately describe the accessibility of streets and sidewalks? How can we make these models and resulting visualizations parameterizable to meet the needs of different users (*e.g.*, manual *vs.* electric wheelchair users)? How can we make our visualizations responsive and interactive over the web (even with 100,000+ data points)? To begin addressing these questions, we report on the initial development of two open-source prototype visualization tools: *AccessScore* and *AccessVisDC*[1].

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[1] Source code and live demos for AccessScore: https://goo.gl/doMR3G and AccessVisDC: https://goo.gl/yn93RZ.

INTERACTIVE PROTOTYPES

Our designs were informed by existing walkability tools (*e.g.,* walkscore.com, walkshed.org), literature on barriers faced by people with mobility impairments [2, 8], our own experience building Project Sidewalk and related systems [5, 6, 9], and two qualitative studies. The first qualitative study included semi-structured interviews and co-design sessions with 20 mobility impaired participants to solicit feedback on three application scenarios with paper mockups: interactive visualizations of neighborhood accessibility (as is the focus here), accessibility-aware location search, and accessibility-aware navigation [4]. The neighborhood accessibility visualization was most the popular scenario, desired by 18 of 20 participants. Suggested features included personalization, being able to see different granularities and abstractions of data, and revealing data source information (*e.g.,* government *vs.* someone with a similar disability).

More recently, we conducted semi-structured interviews with three stakeholder groups (N=12): four government officials, five people with mobility impairments (MI), and three caregivers. While this interview was part of a larger study examining perceptions of urban accessibility and crowdsourced data, interviewers discussed tools similar to Figure 1. The government workers emphasized cost-savings and being able to prioritize areas for physical examination. The MI and caregivers focused more on personal utility, emphasizing that such tools were needed, could enhance independence, and provide more confidence for travel.

Prototype 1: AccessScore

When creating AccessScore, we had three key design tenets: first, while the visualizations could be useful to urban planners, government workers, and other audiences, our primary target users were people with mobility impairments; second, based on our formative work, the system must adapt to individual mobility needs; finally, the visualizations and underlying model should incorporate the proximity to and priority of destinations (similar to walkscore.com).

The AccessScore model discretizes a city into a grid of equally-sized rectangular cells. For each cell, we compute an accessibility score by, first, using the *Google Maps Directions API* to find the n nearest points of interest corresponding to p categories (*e.g.,* library, park, restaurant). We then request a pedestrian route to each destination ($n * p$ destinations in total) from the cell's center and score these routes based on the accessibility data from Project Sidewalk. More specifically, for each accessibility feature along the route (*e.g.,* curb ramp), we add a weight c and for each barrier, we subtract a weight d. The two weights can vary depending on the given accessibility feature, severity, and end-user customizations. We also apply a cost penalty as a function of distance (from [10]). Finally, accessibility scores are normalized based on route length and visualized (Figure 1a; darker colors correspond to less accessible areas).

Because customizable parameters such as selecting mobility level and obstacle weights are factored in during the final steps of the scoring algorithm, many parts of the model can be precomputed, including finding routes to POIs and counting accessibility features/barriers. Thus, AccessScore is performant and personalizable even with 255,000+ data points. However, these optimizations break down if additional POIs are dynamically required. AccessScore is implemented in deck.gl; Python, node.js, and turf.js are used to perform the precomputable steps of the algorithm.

Prototype 2: AccessVisDC

While AccessScore makes it easy to discern "*is this region accessible?*", it is much more difficult to answer "*why does this neighborhood have poor accessibility?*" To address this gap, AccessVisDC provides both a high-level city-wide accessibility visualization—in the form of a neighborhood-based choropleth—and drill-down functionality to explore the raw label data using semantic zoom. From our formative studies, participants wanted to explore different data abstractions and learn more about the underlying accessibility data. In AccessVisDC, users are first presented with an overview interface (the choropleth) but can then zoom in to see a street-level visualization or one level further to see a raw-label visualization. AccessVisDC also provides complementary sidebar visualizations that dynamically respond to user interactions (*e.g.,* a bar graph of accessibility scores is drawn based on highlighted regions of interest).

Unlike AccessScore, AccessVisDC does not currently allow end-users to input their mobility level or customize weights. The underlying accessibility model is also simpler: we simply count the number of accessibility problems within each neighborhood boundary and normalize between 0-1. We plan to study the tradeoffs between the two models and visualizations in future work. AccessVisDC is implemented using mapbox-gl and d3 to provide responsive rendering.

DISCUSSION AND CONCLUSION

In this poster paper, we presented two initial models and visualizations for interactively exploring the accessibility of Washington DC neighborhoods. While our two prototypes were informed by literature and formative user studies, important next steps remain, including: conducting follow-up user studies with our three stakeholder groups, validating our accessibility scoring algorithms, investigating support for other user populations, and publicly deploying one (or both) visualizations for a real-world, longitudinal evaluation.

Project Sidewalk is currently available only in Washington DC. Our team is actively working with partners to deploy in other metropolitan areas. Our long-term goals, then, include supporting cross-city comparisons, evaluating correlates to accessible neighborhoods (*e.g.,* census tract, real-estate, and land use data), and examining the generalizability of our accessibility scoring algorithms. We plan to present interactive demonstrations of both prototypes during the poster session; both tools are also accessible online.

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