

Walk this way: Visualizing accessibility and mobility in metro station areas based on a 3D pedestrian network

Abstract

Accessibility and mobility are positioned differently at the heart of transportation planning; whilst a transportation system with high accessibility is not necessarily be able to support high mobility. In this short article, we evaluate and visualize the accessibility and mobility of pedestrian networks around the metro station areas in a transit-oriented city – Hong Kong. By using the newly released 3D pedestrian network for the whole of Hong Kong under the Open and Big Data Plans, we have created visualizations to compare the 500-meter walking coverage area and reachable area with a 10-minute walking distance that reflects the accessibility and mobility around metro station areas respectively. We find that there are significant differences between accessibility and mobility for some stations. We illustrate the potential underlying causes by comparing three representative pairs of stations as examples.

Keywords: accessibility; mobility; metro; 3D pedestrian; Hong Kong

Accessibility and mobility are positioned differently at the heart of transportation planning (Handy and Niemeier, 1997; Vickerman, 1974) – the former is defined as ease of getting to destinations or activities whereas the latter regards the ease of travelling along transport networks. A transportation system with high accessibility is not necessarily be able to support high mobility. For instance, a multi-layered pedestrian network could help to access a variety of destinations. However, if the layers are connected by overwhelming staircases that increase the walking impendence, even though it provides high accessibility, it could not support all spectrum of mobility needs (e.g., the elderly and disabilities). The importance of policy-performance translation from accessibility planning to mobility realization has been hitherto recognized (Straatemeier and Bertolini, 2020). In transport geography literature, accessibility is usually measured by impedance related indicators (e.g., distance, travel time), attractiveness related indicators (e.g., local accessibility using retail, service, and other employment in a zone), and topology related indicators (e.g., closeness and betweenness) (Cheng and Chen, 2015; Klumpenhouwer and Huang, 2021). Mobility, which can be measured by travel speed (Litman, 2011), aims at increasing the travel distance within a fixed time (Rossetti et al., 2015). City planning enhancing accessibility or mobility would have different strategies, and therefore, a comparison of these two measurements for a system could provide a guide for policy actions. In this short article, we evaluate and visualize the accessibility and mobility of pedestrian networks around the metro station areas in Hong Kong.

By using the newly released 3D pedestrian network for the whole of Hong Kong (links = 436,426, nodes = 371,971) by Hong Kong Government (2020) under the Open and Big Data Plans¹, we have created visualizations to compare the 500-meter walking coverage area and reachable area with a 10-minute walking distance that reflects the accessibility and mobility around metro station areas respectively. The accessibility to metro stations is displayed by the accessible area within 500 meters walking distance in different directions calculated based on the pedestrian network. This creates the boundary of the 500-meter coverage area which mapping to the 2D plane that has access to metro stations. Regarding the mobility of pedestrian

¹ <https://data.gov.hk/en/annual-open-data-plans>. Details of the dataset can be referred to Sun et al. (2021).

to/from stations, we estimate the reachable area in 10 minutes from the station that is acceptable to most people in Hong Kong (Xue and Sun, 2020) using the newly released 3D pedestrian network. We assume the walking speed for adults is 1.3 m/s (Lam and Cheung, 2000), decreasing according to Tobler's (1993) hiking function. We set the lift, escalator, and travelator velocity to be 1 m/s, 0.75 m/s, and 0.9 m/s respectively, same as the recommended values from the Electrical and Mechanical Services Department (2007). Figure 1 shows there are significant differences between the 500-meter coverage area and 10-minute reachable area for 90 metro stations in Hong Kong (excluding stations of border control (i.e., Lo Wu and Lok Ma Chau), Airport, and theme park (i.e., AsiaWorld-Expo and Disneyland Resort)). We sort the stations according to the similarity of the two areas by calculating the Euclidean distance (wildly used as similarity metric (Elmore and Richman, 2001)) of the farthest point of each bin.

We select three representative pairs of stations as examples:

- (1) Individual stations in the central urban area: Hung Hom (HUH) and Sham Shui Po (SSP) Stations are located in central Kowloon: Larger distortion of 10-minute reachable area can be observed at HUH when compared to the 500-meter coverage area. Large building complexes (the Hong Kong Coliseum and shopping mall) located at the east of the station limit the mobility of pedestrians in that direction; on the contrary, an even distribution of the accessibility and mobility in all directions around the station SSP due to the grid layout of network.
- (2) Adjacent stations in the central business area: the Central (CEN) Station demonstrates the enhanced mobility by a multi-layered pedestrian network in the north direction when compared to Admiralty (ADM) station.
- (3) New towns in the New Territories: Tseung Kwan O (TKO) and Statim (SHT) illustrate how transit-oriented planning promotes compact walkable urban development, in terms of their coherent accessibility and mobility. Our visualizations provide initial evidence on the accessibility and mobility gaps based on the 3-D pedestrian network.

Software:

Python 3.7.0 (pandas, numpy, math, pylab)

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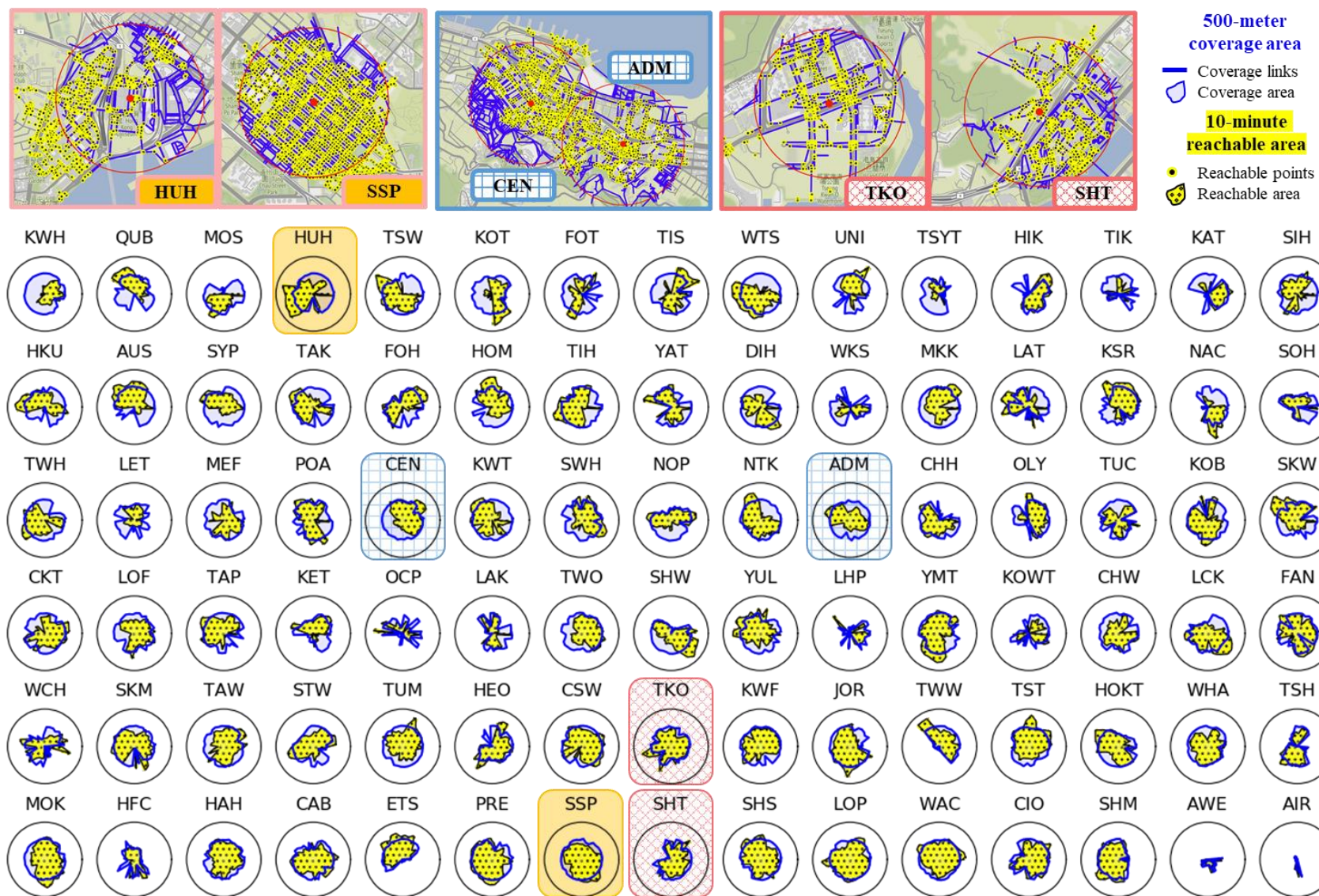


Figure 1. 500-meter walking coverage versus 10-minute reachable area for 90 MTR stations in Hong Kong