Development of a Comprehensive Walking Path System in Hong Kong

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Abstract: Walkability has been defined as the extent to which the urban environment is pedestrian friendly. This article presents a case in Hong Kong of how to develop a walking path system to enable users to choose a pedestrian-friendly route. It is found that different details of land configuration can result in varying paths. Such differences can be significant in contributing not only to an accurate system, but also in convincing and stimulating people to walk more according to their own preference.

1 INTRODUCTION

Walking is a significant transportation mode, and all human beings are pedestrians for varying time periods on roads (Gota et al., 2010). People have to walk for some distances, even when they use motorized transport. Previous studies have shown that public transit users, on average, make at least four walking trips per day (Centre for Science and Environment, 2009).

In recent years, there has been increasing emphasis on environmental and policy initiatives in public health to promote walking activity. Walking is both a means and an indicator to combat global epidemics of non-communicable chronic diseases (NCDs) and overweight (Sallis et al., 2012). Walking can also be considered the basis of the sustainable city, providing social, environmental and economic benefits (Forsyth and Southworth, 2008; Moura et al., 2017).

Walkability has been defined as the extent to which the urban environment is pedestrian friendly. The idea of walkability is that people should become more active in walking in open urban environments (Moura et al., 2017). Pedestrian safety, comfort, and convenience are three elements taken into consideration for walkability assessment (Loo and Lam, 2012). A typical walkability assessment tool is essential, which allows different variables and their relative weights to vary in order to yield meaningful analysis. Recent literature has demonstrated a range of scoring or checklist methodologies to assess the walkability, which enable city planners to audit communities and routes and identify the isolated neighbourhoods to improve walkability (Su et al., 2017).

Geographic information system (GIS) is a collection of spatial data plus the corresponding functions for storage and retrieval, using algorithmic and functional tools to model spatial relationships and spatial reconnaissance (Bartelme, 2012). GIS can be used to assess pedestrian environment that may have impacts on walkability. Nowadays, people are used to search for effective walking routes through Internet and user-friendly Web-based GIS applications such as Google Maps, Baidu Maps, and Microsoft Bing Maps. However, computing and suggesting a pedestrian-friendly walking route is a challenge due to the complexity and diversity of walking path attributes. Although analysis of route paths has been widely used in GIS applications, the integration of various factors (i.e. pedestrian flow, green area, width, brightness, covered area, airconditioner, air pollution) with the analysis of route path is still lacking in the GIS arena (Lwin and Murayama, 2013).

This article presents the development of a walking path system using Central District in Hong Kong as a case study to enable users to choose a pedestrian-friendly route.

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2 STUDY AREA AND METHODOLOGY

Hong Kong is one of the most densely populated city in the world with compact and layered urban structure, mixed land use, and heavy reliance on public transport (Ng et al., 2016). Researches indicated that Hong Kong is a highly walkable city (Kriken et al., 2010; Gota et al., 2010). Through pedestrian-based connections and efficient transportation network, facilities are within easy reach (Lau et al., 2005). Besides, Hong Kong is a three-dimension city, with streets and walkways at multiple levels, above and below ground level, as shown in Figure 1 (Frampton et al., 2012). However, Hong Kong pedestrians tend to be unfamiliar with neighbourhood's pedestrian environment, and less likely to try different routes, which may be due to the lack of route choice or attracted built environment (Guo and Loo, 2013).

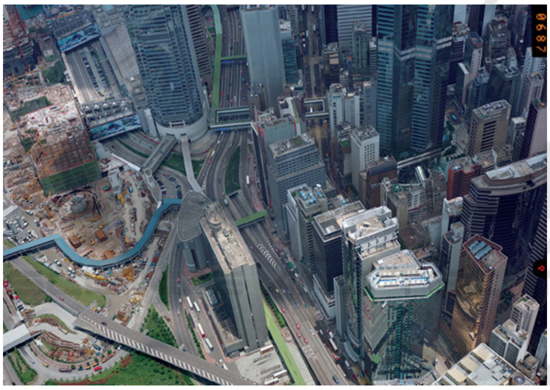

Figure 1: Hong Kong is a three-dimension city (Frampton et al., 2012).

Both government and non-government organizations (NGOs) have taken efforts on improvements of pedestrian environment and walking efficiency, to make the city smarter and more liveable. For example, the Government has fostered the concept of "Walk in HK" under a coordinated strategy, including four themes, namely "Make it smart", "Make it connected", "Make it enjoyable" and "Make it safe", aiming to develop Hong Kong into a walkable city. An app to plan and search for the best walking routes in Causeway Bay as a pilot has also been developed to echo with the Chief Executive's 2017 Policy Address. A local think tank named Civic Exchange developed a walkability measurement tool CEx WALKScore with assessment checklists, and four neighbourhoods (Central, Mong Kok, Kwun Tang, Choi Hung) were selected to conduct walk audits (Ng et al., 2016). A similar study had been conducted by Ng et al. in 2012, in which four local districts (Central, Tsim Sha Tsui, Mong Kok, Ma On Shan) were chosen as examples to create a system on how to assess each route. Another NGO named Walk DVRC Ltd., promotes an urban planning model that gives pedestrians and trams priority over other vehicular traffic, for a more walkable and liveable Central Business District (CBD) that begins with the revitalisation of a decaying Des Voeux Road Central.

The aim of this study is to provide a comprehensive review and scientific analysis of walkability in Hong Kong. To assess walkability, GIS will be used to geovisualize varying urban environmental attributes. Spatial network analysis is performed to model and simulate the characteristics of each link associated with diverse attributes.

Most street network data are readily available from existing official sources from the Transport Department (TD), MTR station maps, HK Tramways Interactive Map, GeoInfo Map from the Lands Department as well as Google Maps. However, many of these do not cover minor narrow streets, indoor and underground paths. These are then supplemented by field survey. Each path segment as denoted from junction to junction is demarcated as belonging to one of the following types – along vehicular roads, crosswalk, footbridge, subway, escalator, staircase and lift. Path attributes like pedestrian flow, traffic flow, degree of greenness, width, brightness, covered, air-conditioning and so on are defined. Table 1 shows the data and sources, description of data, and purpose to use in the project.

To create a walking path network database, edges (line features) and nodes (point features) are defined. Edges are basic elements in network to represent each walking path segment. Nodes are the intersections at points of edges. All elements are properly connected in topological structure. The permitted directions of route are determined by assigning values to restrictions. Impedance is defined to measure resistance of finding walking paths. This parameter can be user-defined such as time, distance, and greenness. Link impedance is the amount of resistance that one has to overcome to travel origin-destination (OD) pairs, while node impedance is the resistance for travelling through an intersection, such as traffic light.

Table 1: Data, descriptions, and applications of their use.

Data and Source	Description	Purpose
Administrative Boundary (TD, HKSAR)	(i) administrative boundary including name, coordinate, feature type; (ii) polygon in an ESRI shapefile	(i) to create a database of building address; (ii) to find desirable and available place; (iii) to perform an address search
Transport Stop (TD, HKSAR)	(i) transport name, type, coordinate; (ii) point in an ESRI shapefile	(i) to create a database of transport stops; (ii) to perform an analysis of walking distance from transport stop to destination
Road Dataset (TD, HKSAR)	(i) road name, type, coordinate, data level; (ii) polygon in an ESRI shapefile	(i) to build a road network model; (ii) to calculate walkability score by building zone
Walking Line (Field Audit)	(i) Walking path name, type, coordinate, data level, attributes including pedestrian flow, traffic flow, green area, width, brightness, covered area, air-conditioner, travel time; (ii) polyline in an ESRI shapefile	(i) to build a walking path network; (ii) to measure network distances between a user-defined point and locations of destinations; (iii) to analyse walkability for each path segment; (iv) to perform an analysis of route based on pedestrian choice
Vertical Lane (Field Audit)		

3 CASE STUDY

A detailed analysis of the pedestrian environment can help improve and increase the walkability of a city. Central District is a representative and good example as it encompasses varying environments and is a busy working district where environments need to be improved to stimulate people walking for a longer distance and time. To be specific, the study area of about 0.8 km² is sandwiched between Queen's Road Central and Central Ferry Piers. Streets include major arterials (e.g. Queen's Road Central, Des Voeux Road Central), and quiet alleys (e.g. Man Yee Lane, Theatre Lane). It is considered as a walkable district, with very good connectivity and accessibility. In total, 729 walking path segments and 79 links to different vertical levels have been digitized. It is also well served by public transportation, with a total number of 128 stops of different modes including MTR exits, tram, bus, ferry and taxi (Figure 2).

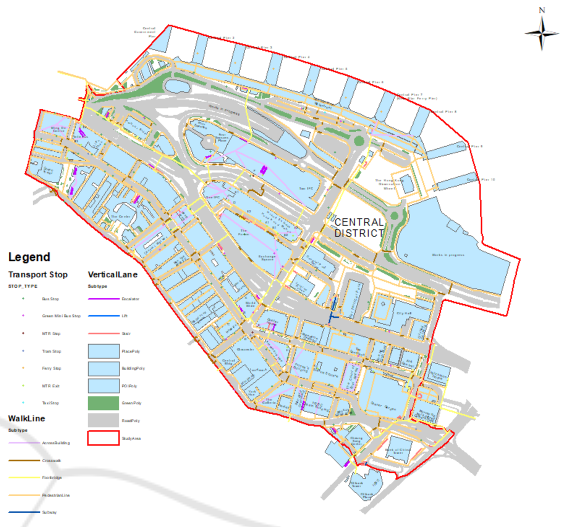

Figure 2: Network Lines in Central by ArcGIS.

The database has following advantages: (i) more paths (i.e. footbridge, escalator, across commercial buildings) are named; (ii) more routes (i.e. across parks/blocks) are established; (iii) detailed attributes (i.e. path name).

This area is predominantly commercial with predominantly high rise office buildings, shopping centres, public buildings, hotels, stores, bars, parks. People may go from one place to another without ever having to leave a continuous network of elevated or underground pedestrian passageways and interconnected malls and office lobbies as shown in Figure 3 (Frampton et al., 2012).

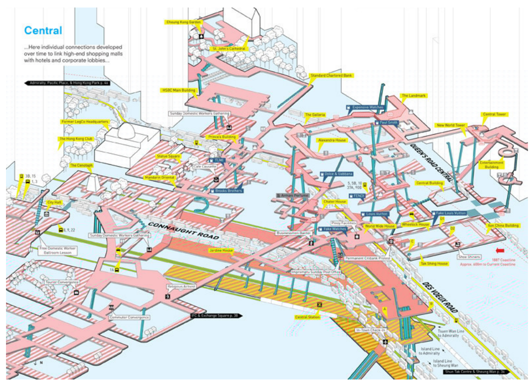

Figure 3: Three Dimensional Drawings of the Elevated Walkways in Central Area (Frampton et al., 2012).

Multiple walking routes are possible between each pair of origin and destination. However, not all pedestrian paths are well connected or designed, such as dead-end streets, narrow paths along driving road. Figure 4 shows a walking path along Queensway for the tram stop ‘Johnston Road (Luard Road)’, which was captured from Google Map. The path is narrow with no fence between walking path and driving road.

Figure 4: Walking Path along Queensway for Tram Stop ‘Johnston Road (Luard Road)’.

4 PRELIMINARY RESULT

In this research, ‘Network Analyst’ function in ArcGIS is performed to select the best route. Take quickest route for example, ‘Time Cost’ is used as restriction attribute that functions as an impedance over the network (Figure 5). Given information about travel time for each walking path segment, spatial network analysis determines the quickest route between each OD pair based on optimization algorithm.

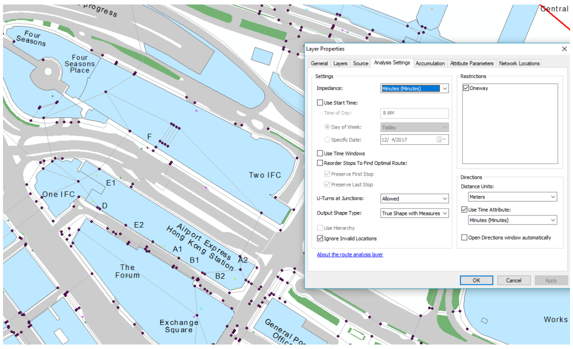

Figure 5: ‘Time Cost’ is used as restriction attribute that functions as impedances over the network.

Random OD pairs have been selected to generate quickest route in our system, and results are compared with Google Map. Figure 6 and Figure 7 shows a route from ‘Cheung Kong Park’ to ‘Central Government Pier’, using our system and Google Map respectively. It is clear that our database has resulted in a more detailed and accurate route due to more paths (i.e. footbridge, escalator, across commercial buildings) and associated attributes.

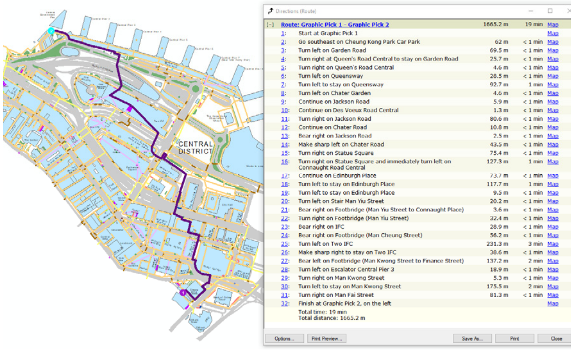

Figure 6: Route from ‘Cheung Kong Park’ to ‘Central Government Pier’ in our system.

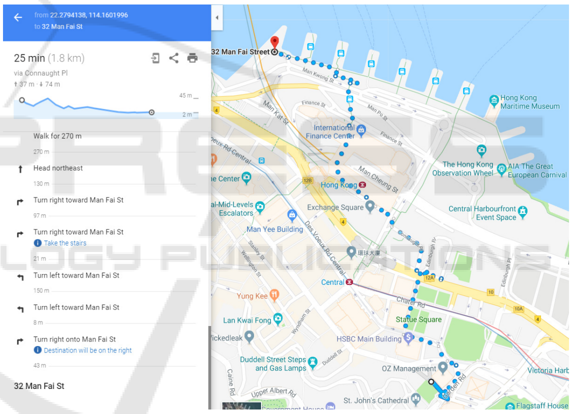

Figure 7: Route from ‘Cheung Kong Park’ to ‘Central Government Pier’ in Google Map.

In another example, Google Map roughly models walking paths surrounding ‘Edinburgh Place’ (Figure 8), while our route is more detailed (Figure 9). Those detailed routes point out the merits and demerits of pedestrian environment, which allow us to identify district-specific and common walkability issues, raise public awareness, seek for solutions with a view to improving walkability in Hong Kong. These routes have also been verified by commuters in the region as to the path segments they actually walk on. To promote walking, a system enabling multiple criteria route finding is crucial to let users understand where and how they should walk according to their own preference. One may choose a fastest while others may choose a safer or more leisurely or less polluted route. To examine the degree to which each path segment can contribute to the selected criterion, a walkability score could be calculated as a weighted factor for each path segment.

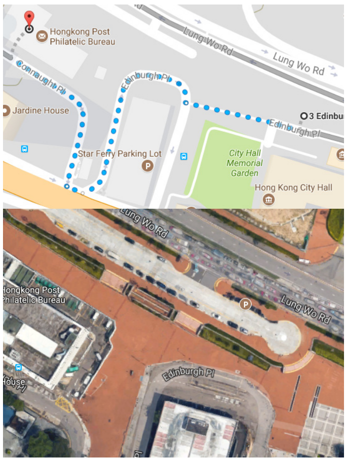

Figure 8: Route along 'Edinburgh Place' in Google Map.

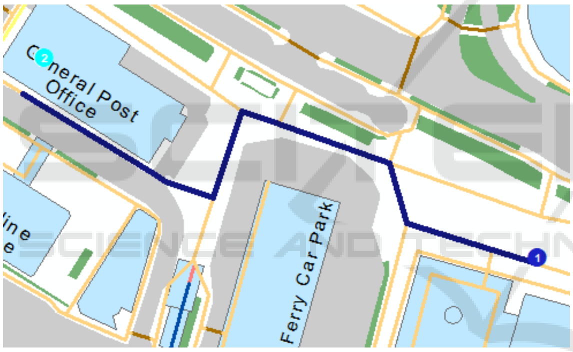

Figure 9: Route along 'Edinburgh Place' in our system.

5 CONCLUSION

To develop a genuine multiple criteria navigation system for walking, a detailed investigation and quantification of varying environmental variables is deemed necessary. With this, we believe people are more stimulated to consider walking as a habit in their everyday activities, and for tourists who would like to explore the city better.

Apart from an accurate and updated spatial database of paths and attributes, an agreement of ranking / weighting varying environmental factors is also important. Many concepts such as safe, leisure, healthy are rather subjective and further studies on human reception and behaviour are needed to develop a system of generally agreeable standards.

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