

Research Assessment Exercise 2020
Impact Case Study

University: The Hong Kong Polytechnic University (PolyU)
Unit of Assessment (UoA): 18 – Planning and Surveying (land and other)

Title of case study: An innovative smart public transport information system

(1) Summary of the impact

Public transport system in Hong Kong may be regarded as the most complex in the world. It comprises a multimodal network of buses, trains, ferries, rail and trams, operated by different companies with varying fare and headway structures. It supports over 12 million passenger trips, accounting for about 90% of the daily passenger boarding in Hong Kong. The HK PolyU team has used its extensive research of pathfinding network to build a detailed route guidance website for any user-chosen origin-destination based on multiple user-criteria. This work has filled an important gap in the services that are being provided to the public, as previously, route planning could only be offered at a company-specific level, making it very difficult for anyone to plan a journey that involved local topography, multiple modes, optimal fare and time.

(2) Underpinning research

The HK PolyU team that worked on this project included three researchers: (Dr. Lilian Pun, Professor Esmond Mok and Dr. Geoffrey Shea). Together, they conducted extensive research on the Hong Kong public transport network, aimed at the development of The Public Transport Enquiry Service (PTES): a multi-modal public transport query and guiding system. Before 2009, there was no such guide; instead, bus companies or MTR websites only provided company-specific route information, making it very difficult for the public to access best-route guides. Therefore, the team developed a multi-modal guiding system that combines information from the various public transport companies operating in the city.

With an area of just over 1000 km², Hong Kong owns the most dense and complicated public transport network in the world. It is characterized by multiple modes of transport: from modern mass transit railway lines (11 MTR & 12 LRT lines) to buses (1318 routes), green minibuses (689 routes) and the traditional modes of trams and ferries (39 routes). There are a total of about 9000 stops, exits, and piers. Each mode is operated by one to tens or hundreds of companies (termed as public transport operators) with varying operating hours (termed as headway) and fare structures. The HK PolyU team mapped the entire network using novel techniques described below.

Although path finding has been studied and reported in many international journals, no existing technique can be effectively applied to the complex public transport network of this big city. Research on route-matching over a large network needs to solve several issues: a) multi-criteria trip planning considering time, cost of non-additive fare structure, transfer, and mode preference; b) topographic barrier of stop accessibility, and c) computational efficiency. Just in terms of the fare, there are very few routes operating on flat fare alone: some have section fare, others have return section fare, and several others have even more complicated fare charts involving concession fare on one or several modes of transport for one or a range of specific stops. Accurately computed routes can enable the prioritization of the most convenient routes according to user-selected criteria of time, fare, transfer, and preferred public transport mode [R5]. However, no existing system has fully achieved this yet. Such a system also needs to take into account real-time differentiation of day and night routes, as well as weekday, weekend, and holiday routes.

To this end, traditional route/path finding algorithms are inadequate. Geo-Information technology has been applied in PTES. This includes real time positioning technology to accurately locate users' origins on a map in a dense city [R6], and rule-based spatial computing for a local context such as algorithms specifically for public transport routing [R5] and for catering circular routes with differential fare structure [R4]. Travel time modelled from different data sources of partial completeness in space and time are also important to suggesting appropriate routes in real time [R1, R2]. Lastly, cartographic techniques for interactive mapping and presentation of maps and CCTV images are applied to various devices such as kiosks and mobile phones [R5]. In summary, PTES has taken into account the local landscape and route configurations, providing the general public with the most comprehensive public transport information and route selection solution that has ever appeared in HK.

(3) References to the research

[R1] Lam, W.H.K., Chan, K.S. & Shi, J.W.Z. (2002) A traffic flow simulator for short-term travel time forecasting. *Journal of Advanced Transportation*, Vol.36, Issue 3, 265-291, DOI: 10.1002/atr.5670360305

[R2] Pun, L., Zhao, P. & Liu, X. (2019) A multiple regression approach for traffic flow estimation, *IEEE Access*, Vol.7, Issue 1, 35998-36009, DOI: 10.1109/ACCESS.2019.2904645

[R3]

[R4] Pun-Cheng, L.S.C. & Chan, A.W.F. (2016) Optimal route computation for circular public transport routes with differential fare structure, *Travel Behaviour and Society*, Vol.3, 71-77, DOI: 10.1016/j.tbs.2015.09.001

[R5] Pun-Cheng, L.S.C. (2012) An interactive web-based public transport enquiry system with real-time optimal route computation, *IEEE Transactions on Intelligent Transportation Systems*, Vol.13, Issue 2, 983-988, DOI: 10.1109/TITS.2011.2181501

[R6] YU, M., LI, Zhi-lin, Chen, Y.-Q. & Chen, W. (2006). Improving Integrity and Reliability of Map Matching Techniques, *Journal of Global Positioning Systems*, Vol. 5, Issue 1-2, 40-46.

(4) Details of the impact

1. Wide adoption in society with positive feedback

The Public Transport Enquiry Service (PTES) was the first multi-modal public transport system, and was launched to the general public in April 2009. It was later renamed as Hong Kong eTransport and became part of Hong Kong eMobility (<http://hkeTransport.gov.hk> or <http://hkeMobility.gov.hk>) in 2019. The system has both online and in-app versions [S1] and has been installed in 15 kiosks all over Hong Kong, including one at the Airport and some at key tourist visiting places [S2]. The team has been maintaining the system and enhancing it to a more comprehensive, informative, and accurate one so that it can compute and filter out reasonable routes between any user-selected origin and destination throughout the territory during its 7x24 hours operation.

The system has become one of the most popular government websites. According to government audit, it was the third most popular government app in 2016 and the second most popular in 2019, after the Hong Kong Observatory [S3]. Additionally, app usage is high. For example, for the period July-August 2019, there were more than 100,000 daily route-planning requests on average [S4] and more than 2 million downloads of the iPhone and Android apps [S5]. Hong Kong eTransport was also publicized in several newspapers, magazines, and TV channels after it was first launched. It has been cited by government officials and legislative councillors as a successful product related to

Intelligent/Smart Transportation Systems in Hong Kong [S6]. In 2015, an online user survey (with 1931 respondents) and a focus group meeting (with key operators and transport professionals) were conducted [S7]. Their feedback was overwhelmingly positive: about 90% of the participants found the criteria and design parameters satisfactory. Their constructive recommendations for improvements have been incorporated into enhancements in recent years.

[REDACTED]
[REDACTED]
[REDACTED] While PTES demonstrates a good collaboration between the Hong Kong Polytechnic University and the Government, we are glad that this service has contributed a lot for the development of Smart City” [S5].

2. Enhancements for multi-user requirements

The PTES system has been improved to satisfy users’ and public transport operators’ requirements. From 2013 to date, these include but are not limited to [S5]:

- a) Improving the route search algorithm by taking into consideration local topographical barriers and improving the use of the advanced search and filter logic with at most two consecutive bus-bus interchanges.
- b) Improving the accuracy of travelling time information by incorporating differential speed limits for each road segment and real-time timetable/headway information, integration of real-time bus arrival systems for public transport operators, and walking time between each MTR exit and the train platform.
- c) Developing APIs for various deployments, such as kiosks, at different places in Hong Kong, the Airport Authority, and MTRC website, and the development of the elderly mode version.

Funding for further development of the system is expected to include the incorporation of walking paths to the stops, real time alert of closing stops/stations and computation of alternative routes due to emergencies such as typhoons.

3. Information support for transport-related policy makers and other operators

With the success of PTES/HKeTransport, the project has led to another consultancy [REDACTED]

[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED] [S8].

Additionally, since the launch of the system in 2007, other public transport operators, including MTRC, KMB, and NWFB, have improved their own guides by incorporating maps and photos. In 2019, MTRC linked their guide to the PTES/HKeTransport system to modify their own MTR mobile trip planner system [S5, S9].

4. Big data for public access

Data generated for the HKeTransport has been uploaded regularly [REDACTED] [S10], [REDACTED] for general and educational use. Usage is high, with an average of 5,000 downloads per month [S5]. The big data generated from public transport information is invaluable to further research and policy-making.

(5) Sources to corroborate the Impact

Refer to the attached appendix for details of some of these sources.

[S1] Website of HKeTransport:

<https://www.hkemobility.gov.hk/> (previously before 2018, it was <http://hketransport.gov.hk>)

[S2] HKeTransport kiosks:

<http://www.info.gov.hk/gia/general/201606/23/P201606230379.htm> (2016)

[S3] [REDACTED]

[S4] [REDACTED]

[S5] [REDACTED]

[S6] Extract from Ta Kung Pao (23 Dec 2016):

www.takungpao.com dated 23.12.2016

[S7] [REDACTED]

[S8] [REDACTED]

[S9] MTR Mobile, Trip Planner:

<http://www.mtrmobileapp.com/en/trip-planner.php>

[S10] [REDACTED]