A Study and Design of Transit Map based on Visual Perception

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ABSTRACT

Transit maps can be designed in infinitely many different styles but not all of the designs are equally effective. To design an efficient transit map, it is important to understand route selection of passengers based on their visual perception. This paper developed six different transit maps and conducted a route selection experiment to explore the impact of using transit map as a planning tool to influence passengers' travel decisions to find the fastest route in the Bangkok Mass Transit System (BTS) and Metropolitan Rapid Transit (MRT). The experiment with 90 participants was conducted through a paper-based survey of six travel decisions per map design. The results show that different map designs significantly affect the participants' accuracy and time to find the fastest route.

Keywords: transit map, route selection, visual perception.

1 INTRODUCTION

A transit map is a representation of a transportation network and probably the single most important information source for the transit system's passengers. It provides passengers essential information such as entry, exit, and transfer stations.

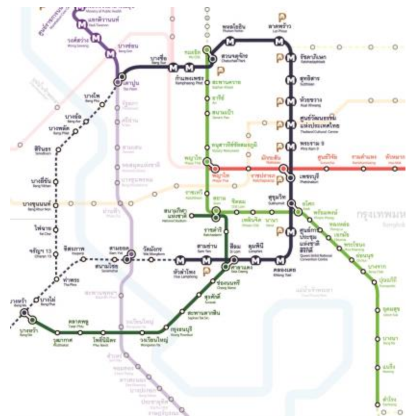
The map can be designed in various styles. Despite many possible visuals for transit maps, they have similar basic components of each network: station indicators, station names, line identifiers or names, and interchanges. Color coding is used to differentiate each line from other lines [1]. Passengers perceive information delivered by a transit map through map design. Different designs of each component likely affect passengers' visual perception and can lead to misunderstanding. To design a transit map, it was essential to understand how passengers perceive information from each symbol.

Although a transit map shows the locations, directions, and connections of stations and lines, it normally does not include service information, such as transit fare or crowdedness [2]. The most common and important variable to explain route choice behavior is travel time. Passengers tend to look for the fastest route to travel from their origin to their destination. They have to estimate the time needed to travel, distance to the destination, and planning which transfer to make.

This paper uses a route selection experiment to study the effect of different transit map designs and to answer our research questions which are (i) which design of transit map accurately provides passengers the fastest route? and (ii) what are the relevant factors that affect passengers' route selection within transit system?

2 STUDY DESIGN

This paper focused on the design of printed maps for rapid transit systems in Bangkok, Thailand. We adapted the official BTS and MRT maps, shown in Figure 1, as the base of six different transit map designs. In the experiment, the official BTS and MRT maps were excluded.



Official BTS and MRT map. [3]

2.1 Map Design

A transit map is a form of diagram that illustrates the lines and stations within a transit system. Unlike a general map, a transit map is rarely geographically accurate. Map distortion changes the lengths and directions of lines and the locations of stations by making the lines straighter, fixing the line angles, and sometimes fixing the distance between stations [4]. Such distortion can attract the passengers' attention to points of interest and the route between them can be more easily derived from a map. Note that a transit map normally includes at least one geographic feature, such as a river, as a mental anchor.

Apart from map distortion, it is essential to denote connections on a transit map. A transfer station is a special station and can be further divided into two types: the same station with more than one line (*Siam* in the BTS system) and two or more separate stations connected by a walkway into one cluster (*Asok* in the BTS system and *Sukhumvit* in the MRT system, for example). They are usually encoded in different ways but there are many styles. Two styles are shown in Figure 2, as follows.

a) One circle to represent the same station and two circles without a link for two separate stations.
b) Oval with two triangles inside to represent the same station and two circles with a link for two separate stations.

Two styles of transfer stations. (a) shows no transfer information while (b) shows the transfer information by using a different symbol or adding a connection between two stations.

Similar to map distortion, different encodings of a transfer station likely affect the passengers' transfer decision in transit system. Some other factor might affect passengers' perception and route selection, such as map size and travel experience.

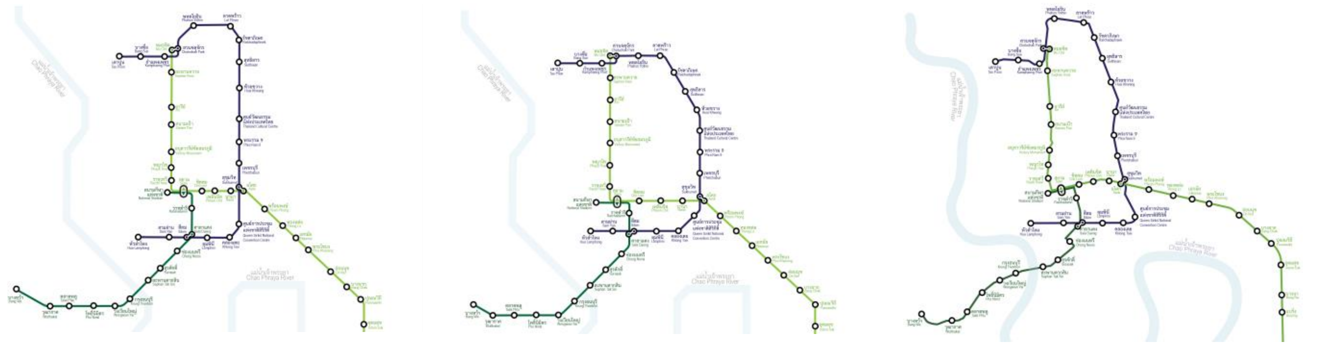


Figure 3: Three route characteristics design, namely a distorted map with actual distances between stations (left), a distorted map with fixed distances between stations (center), and a geographically accurate map (right). All of them are shown with the second style of transfer stations.

2.2 Route Selection Experiment

We focused on two common characteristics of a transit map; transfer station design and map distortion, specifically simplified shapes and distances between stations. As it is contradictory to have a geographically accurate map with fixed distances between stations, there are only three variants of route characteristics, depicted in Figure 3. Combined with two different transfer station designs, we designed six maps in total.

We conducted a route selection experiment through a paper-based survey. There were 90 participants (48 female and 42 male Bangkok population, aged 15 to 59). Each participant received a randomly selected map from the six possibilities. There were six pages of the same map with different origin and destination station pairs. He or she was then asked to draw a selected route onto each page. The dependent variables are the accuracy of the fastest route and the time to complete travel decisions. In this survey, demographic information and travel behavior were also collected in order to analyze whether the frequency and familiarity of transit system affected the answers.

3 RESULTS AND DATA ANALYSIS

Once results have been collected, we used an ANOVA (Analysis of Variance) to test whether line simplification affect the accuracy and time to find the fastest route and we used t-test to compare the mean of the accuracy and time to find the fastest route on distances between stations and transfer station design.

We found out that the participants spent 3 minutes 38 seconds on average to complete six travel decisions. For the geographically accurate map, the average time to complete the route selection was almost 5 minutes, while the average time for the distorted map with actual distances between stations was 3 minutes 12 seconds and for the distorted map with fixed distances between stations was only 2 minutes 20 seconds. The result shows there was a significant difference in the means of the time to find the fastest route on different line simplifications at 95% confidence interval (F-ratio = 4.86 which is greater than F-critical = 3.11 means that the null hypothesis should be rejected). However, map with different distances between stations and transfer station had no significant differences on average time to find the fastest route.

Although the participants took much time on the geographically accurate map, their answer on the fastest route on all six maps were similar. 75% and 67% of the answers were correct on the geographically accurate map and both of distorted map styles, respectively. The result shows there was a significant difference in the means of accuracy to find the fastest route on different line simplifications at 95% confidence interval (F-ratio = 3.25 which is greater than F-critical = 3.11). Unsurprisingly, map with different distances between stations and transfer station had no significant differences on average accuracy to find the fastest route.

4 CONCLUSION AND FUTURE WORK

In this paper, we carried out a route selection experiment aimed at finding which map feature affects the passengers' fastest route selection. We considered three map features: line simplification, distances between stations, and transfer station design. Using geographically accurate map, passengers accurately selected the fastest route. In other words, passengers perceived actual travel time on geographically accurate map. Although it enhanced planning accuracy, the passengers spent more time on decoding transit lines and selecting the best route. The most effective transit map design depended on expected result, such as the fastest route or the least route-finding time.

In the future, we would like to verify whether other factors affect the time to complete travel decision and accuracy of the fastest route. Moreover, we are interested in applying the results to automatically generate transit maps using our criteria approach [5] that conforms to our findings.

REFERENCES

[1] Bain, P., Aspects of Transit Map Design. *Parsons Journal for Information Mapping*, 2(3), p.2, 2010.

[2] Guo, Z., Mind the map! The impact of transit maps on path choice in public transit. *Transportation Research Part A: Policy and Practice*, 45(7), pp.625-639, 2011.

[3] Bangkok Expressway and Metro. (2018). MRT Route Map.

[4] Guo, Z., Zhao, J., Whong, C., Mishra, P. and Wyman, L., Redesigning subway map to mitigate bottleneck congestion: An experiment in Washington DC using Mechanical Turk. *Transportation Research Part A: Policy and Practice*, 106, pp.158-169, 2017.

[5] Stott, J., Rodgers, P., Martínez-Ovando, J., & Walker, S., Automatic Metro Map Layout Using Multicriteria Optimization. *IEEE Transactions On Visualization And Computer Graphics*, 17(1), 101-114, 2011.