Visual Task Solution Strategies in Public Transport Maps

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Abstract. Public transport maps are used as visual aid for travellers to support the route finding task from a start to a destination. Although those maps are designed in a user-friendly manner by applying effective layouts, color codings, as well as intuitive symbolic representations it is unclear which perceptual, readability, and understandability problems the human user has when looking at those maps. In a preliminary eye tracking experiment with 8 participants, we asked people to find a way between highlighted start and destination stations on different maps. Based on a visual scanpath analysis, we discovered a set of different visual task solution strategies that will build the foundation for hypotheses to evaluate in a final user study.

Keywords: Public transportation, metro maps, eye tracking, evaluation

1 Introduction

Travelling in a foreign city is a common scenario for people all over the world. To find at least one way from a start to a destination is oftentimes solved by inspecting a metro map typically placed as a poster at a station's wall.

Although many attempts have been made to improve the layouts of the maps, the color codings, the symbolic representations, as well as additional tourist information it is unclear how people's eyes behave when getting confronted by a route finding task. This task may be supported by advanced interactive displays but in many metro system locations it is unrealistic to give the passenger such an opportunity due to the increase of additional costs of those advanced technologies. Consequently, the only way for finding a route in the metro map is by looking at static pictures of it which make this user study important.

To this end we conducted an eye tracking experiment to find out which visual task solution strategies are applied by the study participants when searching for such a way. A visual task solution strategy in the context of this work is defined as a common eye movement principle with which people solve a given task. To reach this goal, we subsequently showed them metro maps of different complexities, i.e. the maps of Stuttgart, Hong Kong, and Paris and asked them typical route finding tasks. To reduce the cognitive load of a search task we highlighted start and destination stations by a green and a red circle.

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2 Related Work

Public transport maps have been designed a long time ago and have been made prominent by early work of Harry Beck [9]. This initial design has been improved step by step by applying different layout strategies, color codings, or symbolic representations as well as additional information [4] such as labelling [7] [12]. Although many attempts have been made to improve the readability and intuitiveness of those maps the usability for the human user has only been investigated in a small number of studies by tracking the eyes of the user while inspecting it.

In our former work [3] we reported on the results of an eye tracking study to find out how people read such metro maps. In this work the results are presented based on completion times and where people look at most frequently. Those insights in the eye movement data are depicted by heat map visualizations [2]. From this analysis we learned that people more frequently focus on start and target stations but also on possible interchange points. Moreover, in some scenarios we saw that people followed different routes to solve the task reliably. The results based on completion times as a pure dependent variable show that there seems to be an increase depending on the complexity of the shown maps.

All of these explorations were derived from looking at either statistical data such as completion times or inspecting the fixation duration distribution by visually encoding them into heatmap representations. Although heat maps are powerful for showing frequently visited areas those are not able to show time-varying visual task solution strategies which is in focus of this work.

To this end, there are some user studies for general node-link layouts for graphs but eye tracking studies in this field of application are rare. For example, metro maps can be interpreted as planar graphs visualized in a node-link metaphor. An eye tracking experiment by Huang et al. [6] uncovered that people follow the geodesic path tendency when finding a route from a start to a target node [10] which is also an interesting scenario in our work.

3 Eye Gaze Analysis

We designed an eye tracking study in which we presented real-world metro maps as static stimuli. The only task to be solved was finding a route from a highlighted start to a destination station. In the present paper we take a different look at the formerly recorded eye movement data [3]. The data was recorded in a user study with a within-subject design with the three different metro maps and varying start and destination stations acting as independent variables. Counterbalancing was performed by permutating the display order of the metro map complexities. In summary, each participant investigated 9 different combinations of maps and stations. We extend our analysis by investigating time-varying and spatio-temporal eye movements in order to derive common visual task solution strategies. We analyze how people actually solve such a route finding task and in particular, how they behave at interchange points. The question is if there is a commonly applied strategy among the participants or if they behave totally different.

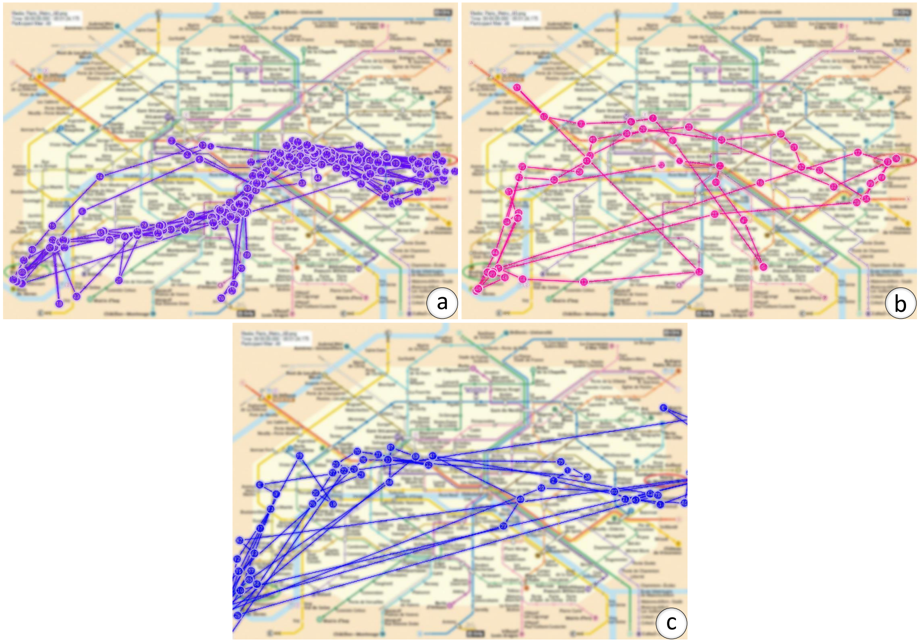

Fig. 1. Gaze plots for the Paris metro map for a single participant: (a) Clearly visible route with short saccades. (b) Different route from that in (a) is chosen with longer saccades. (c) Similar strategy as in (b) but more cross checkings are done (longer saccades from bottom left to center right).

The displayed maps were manually selected from looking them up on the world wide web. We focus on the readability of the text labels since those are taken as reference points during the study to explain the operator where metro lines must be changed.

The gaze plots in Figure 1 for Paris for three single participants unhide different task solution strategies. In Figure 1 (a) one can see that the participant is making short saccades to follow the metro lines from start to target station. This is caused by frequently checking subsolutions on the route meaning frequently jumping to and thro with the eyes. In (b) the saccades are much longer but also here a clear route can be detected. In (c) the strategy looks similar to that in (b) but many more cross checkings between start and target station occur.

In general, we could identify 6 visual solution substrategies by a visual scanpath analysis of the gaze plots:

1. **Searching and locating start and target stations:** Before answering the route finding task the participant has to search for highlighted start and target stations. If those can be found preattentively this stage will not take a long time.
2. **Finding a geodesic path between start and target stations:** The best route would be one which lies on the direct way from a start to a target

station but generally there is no straight route. Consequently, one has to look for one which might be close to that.

3. **Building a set of possible metro lines:** When looking for an effective route the viewer is taking the different color codings of the metro lines into account. This helps to solve the task more effectively. In this stage a set of possible metro line candidates is built.
4. **Estimating possible interchange points:** From the set of possible metro line candidates one has to find out possible interchange points. A lot of time is wasted here in order to check if those interchange points are really suitable to solve the task.
5. **Partially solve the route finding task between interchange points:** The route finding task is now splitted into a sequence of subtasks. This means the route finding task must now be solved for routes between interchange points.
6. **Cross checking the complete found route:** After having solved all those subtasks the complete route is now cross checked for correctness. This process may also be done several times until the participant is sure to have found one route.

Based on these observations, we will formulate our hypotheses for a follow-up study with an increased number of participants. To evaluate the results of the study, an extended analysis will be necessary to support the hypotheses concerning the different strategies. Therefore, we consider applying scanpath similarity measures [5] in combination with a visual scan path analysis by scarf plots [8] to provide quantitative measures and more advanced visual representations of the data besides the basic analysis of gaze plots.

4 Future Work

In this preliminary study, we investigated by eye tracking how people solve a route finding task in metro maps. We identified 6 different visual reading substrategies that were performed to solve the tasks. Based on these findings, we will conduct a follow-up study with an extended evaluation of the recorded eye movement data by established fixation-derived and saccade-derived eye tracking metrics [11]. Depending on the stimuli, we will also investigate where Areas of Interest can be defined, to further extend the analysis of eye tracking metrics. We also plan to investigate to which extent existing advanced visual approaches for the analysis of eye tracking data [1] can be applied in our case. In the follow-up study, we will investigate metro maps of different complexities and a varying number of interchange points between a route from a start to a target station to vary the complexity of the routes. Another aspect to be analyzed is the impact of color coding which we will compare by also showing the metro map stimuli as gray scale images.

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