

Usability Test of Map-based Interactive Dashboards Using Eye Movement Data

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Abstract Map-based dashboards support users to extract and reveal spatial data into insights. Understanding the cognitive process of users during their interactions with map-based dashboards is important for designing useful dashboards. However, there are little studies about users' sense-making procedures of map-based dashboard usage. This study tries to find out the usability of map-based interactive dashboards in users' insight revealing process. An experiment is designed to collect more than 40 users' eye-tracking data for four predefined tasks. The eye movement data will be quantitatively analyzed using descriptive statistics, and the qualitative questionnaire data will be summarized thematically. The results should support better communication of geoinformation map-based dashboards.

Keywords: map-based dashboard, eye-tracking, geo-data visualization

1 Introduction

With the increasing amount of socio-economical measurements, the difficulties of sense-making and communication of number-rich datasets are rising. Map-based dashboard conveys multi-dimensional spatial information by the intuitive visual interface, which makes the knowledge understandable. Moreover, the interactive map-based dashboard carries in-depth information by enabling the communication between the visualizations and the users (Sarıkaya et al., 2019). However, little studies about the users' spatial sense-making procedure of map-based dashboards



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are conducted. Kiefer et al. (2017) inferred that eye movement data externalizes the human cognitive process and thus opens a deep understanding of cartographic perception.

Yalçın et al. (2018) studied the insights winning procedure of the users. The experiment was proceeded as the users freely explore a dashboard with the think-aloud method. They have found that less familiar interactivities are more likely lead to incorrect understanding. Additionally, personal differences result to various insight-finding strategies and insights. Bogucka and Jahnke (2018) compared the usability and feasibility of two different cartographic representations with predefined tasks. Eye-tracking data were collected to analyze users' searching strategy, and post interviews were conducted to compare users' preference. Popelka et al. (2019) evaluated the usability of three map-based dashboards with the eye-tracking experiment, which is designed in a combination of free-viewing and task-solving parts. Moreover, the users' searching strategies were visualized and analyzed with the sequence charts.

However, the tasks of the aforementioned studies focused on object identification of the dashboards. The sense-making procedure of more complex tasks, e.g., spatiotemporal trend summarizing, multi-variable spatial correlating, need to be further studied. Therefore, we plan an experiment to explore the differences in the insight winning procedure of given tasks with different complexities. Eye movement data will be collected to reveal the users' visual searching strategies. The results may support the cognition-based geo-data visualization and guide the dashboard design and application.

2 Methodology

We will examine the usability of interactive map-based dashboards through a case study about socio-economic ecosystem in Yangtze River Delta, China. A dashboard is designed to visualize the industrial-related indexes, e.g. the numbers of company, gross domestic products (GDP), population, to support the local entrepreneurs' decision-making. The tasks of the experiment vary in complexity, with identification and summarization cognitive operations respectively. The users' eye movement data will be collected during the experiment. Finally, the effectiveness, efficiency and the task-solving strategy will be analyzed.

2.1 Apparatus

In this study, we will use Gazepoint¹ GP3 Desktop Eye-Tracker, which is with 0.5 -1 degree of visual angle accuracy and 60 Hz update rate, to keep track of participants' eye movement. The eye tracker works with a 3840 x 2160 resolution monitor. The software Gazepoint Analysis will be used to analyze the eye movement data.

2.2 Participants

We plan to recruit at least 40 participants (twenty females and males each) by leaflets and online advertisements. The participants should have different backgrounds, computer skills and previous experience of web-based dashboard. To get the gaze data with high quality, they should have normal or corrected-to-normal eye vision. Besides, they should not have serious mental illnesses.

2.3 Interfaces

For the purpose of this study, we acquired socio-economic data, i.e., enterprise number, GDP, population and logistic related data, from 2013 to 2015 in Jiangsu China. The data is based on a unit of county and city². We designed and implemented an interactive map-based dashboard for users to explore, correlate and analyze the regional socio-economic variables and acquire knowledge. Specifically, small multiples are implemented in favor of correlating, and as the main interaction tool. The interface is shown as Figure 1.

In addition, users can active a county by clicking on either of the four maps, and active the layers from the layer button in the top right of each map. The content of *Panel B-E* is linked. The visualizations in *Panel B, D* and *E* changes according to the users' interactivities in the *Panel C*. Moreover, the four maps are synchronized. If a user zooms or drags one of the maps, the other maps will follow.

¹ <https://www.gazept.com>

² In China, a city includes several counties.

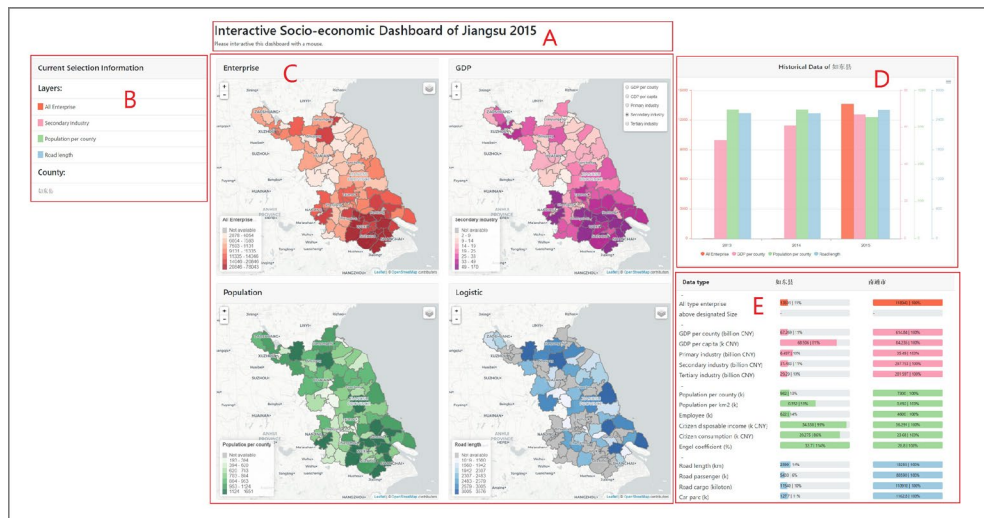


Figure 1: The interface of the map-based dashboard for socio-economic indexes visualization in different perspectives. *Panel A* presents the title and background information. *Panel B* shows the active layers and the name of the active place. *Panel C* is the map view, presenting the spatial distribution of the variables of the same area. *D* displays a histogram of active attributes at a selected place. *E* is a table view, showing all the variables in detail of a selected place and its affiliated city.

2.4 Task setup

Based on the usability design of Popelka et al. (2019), we designed the tasks of using the map-based dashboard at different complexity levels. The following tasks are designed:

- *Task 1:* Please find the county with the largest number of enterprises of the province.
- *Task 2:* Please find the Tertiary industry value of the county *Qidong* in 2015 and the percentage in the affiliated city.
- *Task 3:* Please summarize the spatiotemporal pattern of the GDP index of the whole province.
- *Task 4:* Please find the correlation between Enterprise and Population.

The tasks differ mainly in complexity. T1 and T2 are identifying tasks, which can be solved by objects finding from the dashboards. While T3 and T4 are summarizing tasks, which require users process the information based on their interaction and observation from the dashboards. Moreover, T3 focuses on the trend summarization of only one variable, whereas T4 focuses on correlating two variables. The tasks settings are described in Table 1.

Table 1: The task setting to assess the usability of map-based dashboard.

Task	Cognitive operation	Description
T1	Identify	Find a place according to the spatial trend.
T2	Identify	Find the values of variables at a certain place.
T3	Summarize	Describe the spatiotemporal trend of one type of variable.
T4	Summarize	Compare the spatiotemporal trend between two types of variables.

2.5 Procedure

The experiment will take place at the Eye Tracking Lab at the Technical University of Munich. Before the experiment, the participants will be introduced of the experiment procedure and the data privacy policy. The experiment will be proceeded when the participants agree and sign a written consent. In addition, the participants are allowed to exit the experiment at any point during the experiment.

During the experiment, we will first introduce the background of the dashboard to the participants. Secondly, the participants will be given a dashboard instruction and asked to explore the dashboard freely for three minutes. Thirdly, after calibration of eye position, the participants' eye movement will be recorded while they are asked to complete a set of the predefined tasks by freely interacting with the dashboard. The participants are required to refresh the dashboard after every task is finished.

After the task session, we would give the participants a questionnaire to fill their personal information, i.e. gender, age, education level, profession, computer skills, and their subjective opinions regarding the dashboard usability.

2.6 Analysis

A series of qualitative and quantitative analytical methods will be performed to examine the usability of the dashboard. Firstly, the correctness of each tasks regarding both interfaces will be analyzed respectively. Secondly, we will analyze the task-solving durations respectively. Thirdly, a visual analytical method, will be applied to study the task-solving strategy. More specifically, for each task, 1) a heat map of all the participants' fixation, 2) a scan path map of all the participants' eye movement, 3) a sequence chart of every participant's eye fixation duration across panels will be created and analyzed. Finally, the usability statements of map-based interactive dashboard will be derived from the previous analysis and the questionnaire results.

3 Summary and Outlook

The ongoing study addresses eye movement data with the aim to access the usability of the map-based interactive dashboard for insight revealing in socio-economic data for given tasks.

The tasks are ordered by the relative complexity of winning the insight. At least 40 users will be recruited as subjects of the experiment, and a post-study interview will be used to summarize the usability of dashboards, thus guide the improvement of the dashboard design.

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