Gaze-Based Interaction with Maps and Panoramas

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Abstract. Novel interaction methods based on eye tracking can help users of location-based tourist guides to retrieve information about touristic features in the environment. However, these Gaze-Informed Location-Based Services (GAIN-LBS) do not assist their users with orientation. Here, we introduce Map-Enhanced GAIN-LBS which extend GAIN-LBS by an interactive map that provides extra information about the user's location and the inspected touristic features. The system is evaluated with a between-subjects study.

Keywords. Gaze-Informed Location-Based Service, tourist guide, orientation, interactive map, eye tracking, gaze-based interaction

1. Introduction

Tourists at vantage points often have problems with orientation and with identifying features in the panorama. Even though information can be retrieved from fixed installed panorama boards, classic audio guides, or mobile maps, it is often not easy to efficiently and effectively match the described objects with the view. While tourist guides have always attracted the attention of Location-Based Service (LBS) researchers, most systems have focused on audio- and map-based interaction (Raper et al., 2007), while other communication modes are still largely underexplored (Huang et al., 2018).
Here, we suggest to combine three communication modes for interacting with an LBS: gaze, audio, and maps (Gkonos et al., 2017). The use of gaze is motivated by eye tracking technology becoming increasingly pervasive (Bulling et al., 2011) and starting to enter the mass market (e.g., HoloLens 2 by Microsoft[1]). We thus enhance the recently proposed Gaze-Informed Location-Based Services (GAIN-LBS) (Anagnostopoulos et al., 2017) by an interactive map component, aiming at improving tourists' orientation.

[1] https://www.microsoft.com/de-ch/hololens/hardware (visited 10 July 2019)

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2. Map-Enhanced Gaze-Informed LBS

GAIN-LBS determine the orientation of the head with regards to the surrounding environment by analyzing the image obtained from the front view camera of a mobile eye tracker. Anagnostopoulos et al. (2017) described the system implementation and an evaluation for indoor and outdoor settings. Here, we propose to enhance GAIN-LBS with an interactive map to help with orientation. The system detects the area of interest (AOI) the user is looking at, such as “Rigi mountain”. As illustrated in *Figure 1*, users can then listen to information about the AOI and obtain extra information via the interactive map. The spatial extent of the AOI is visualized on the interactive map and shown together with a list of attractions in this area. Users can select the listed attraction they want to know more about. Information is provided via audio, and the location of the attraction is additionally drawn on the map.

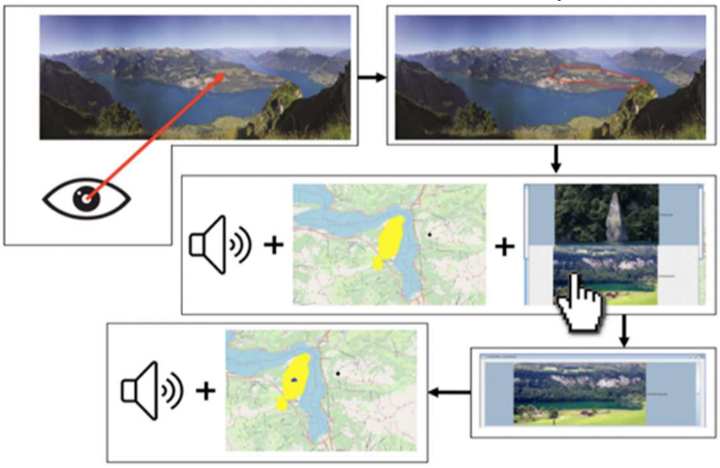

Figure 1. Flow of interaction for the Map-Enhanced Gaze-Informed LBS.

3. User Study and Results

The goal of the study is to test whether gaze-based interaction has the potential for improving tourists’ orientation, compared to a regular map without gaze interaction. A between-subjects study was carried out, comparing the baseline condition (condition A, i.e., a regular interactive map with pan and zoom) to a Map-Enhanced GAIN-LBS (condition B, *Section 2*). The rationale for including a map in both conditions – instead of using GAIN-LBS without map as a baseline – was to make the comparison regarding the spatial orientation tests fairer. This study focuses on the following research questions:

- RQ1) Do Map-Enhanced GAIN-LBS help to orient in the environment?
- RQ2) Do Map-Enhanced GAIN-LBS help to better situate and memorize what has been seen in the environment?
- RQ3) Do Map-Enhanced GAIN-LBS help to transfer the local position to a higher-level reference system?

3.1. Study Design

18 participants (7 females) participated in this user study (avg. age 22.9 yrs). Participants were equally and randomly assigned to the two conditions. The experiment was carried out in a room with a large panorama wall (5 x 2.3 meters, see *Figure 2*). Eye tracking data from an SMI 120 Hz eye tracker were used as input for the system.

Written informed consent was obtained. Questions about basic demography, familiarity with the area of the panorama view and the German version of the Santa Barbara Sense of Direction Scale (SBSODS) questionnaire (Universität Freiburg, 2011) were asked in the pre-questionnaire. Results of t-tests suggest that the two groups had similar orientation abilities ($t(16) = -0.137$, $p = .893 > .05$) and similar familiarity ($t(16) = 1.128$, $p = .276 > .05$).

During the experiment, participants could explore the view and use the (interactive) map freely for a maximum duration of 10 minutes. All participants in condition B were stopped by the experimenter after 10 minutes, while for condition A they spent an average of 8.67 minutes (SD= 1.15). Participants were then asked to fill in the post-questionnaire.

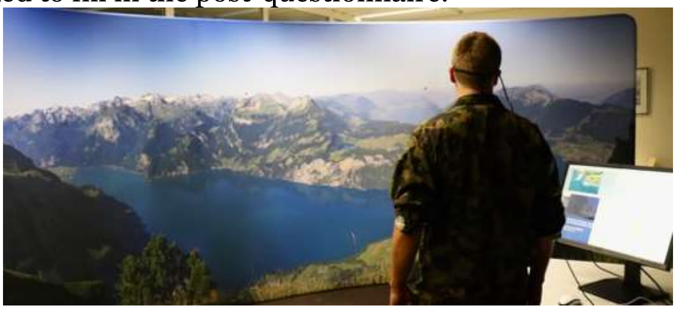

Figure 2. Experiment setup: a participant with eye tracker in front of the panorama wall.

3.2. Results

3.2.1. Usefulness of the Map

The post-questionnaire included three 7-Likert scale questions: "The map helped me to locate myself better in the environment", "The map helped to locate the areas", and "I am more familiar with the region after using the system". The t-test results show that condition B was rated similar to condition A in terms of helpfulness in locating oneself in the environment ($t(16)=0.677$, $p=.508 > .05$), locating the area ($t(16)=0.899$, $p=.382 > .05$) and increasing familiarity with the region ($t(16)=1.203$, $p=.247 > .05$).

3.2.2. Estimation of the Compass Direction

The view from the location of the panoramic photograph to Lucerne is directed to the northwest (NW) or to the west (W). Only 56% participants of condition A were able to indicate the direction to a specific AOI of the panorama correctly, while 89% participants of B selected the correct answer.

3.2.3. Memorizing Information on AOIs

The number of AOIs visited was on average 7 to 8 AOIs in condition B, all 14 AOIs in condition A. The open-ended questions "Which places did you look at?" and "What do you remember about these places?" were evaluated. The percentage of the AOIs remembered (out of the AOIs looked at) was calculated. Participants from condition B could remember almost 80% (SD= 34.16%), while those from A could only remember about 51% (SD= 21.87%). Meanwhile, on average, participants in condition B (M = 2.17) were able to list more pieces of information than those in A (M = 1.04, $p = .001 < .05$).

3.2.4. Drawing the Memorized Objects

Participants had to draw a sketch panorama and a sketch map based on their memory. The sketches were evaluated with the software GMDA (Gardony Map Drawing Analyzer; Gardony et al., 2016) for calculating the similarity between the sketches and the target panorama or map. Five key values were calculated: canonical organization, scaling bias, distance accuracy, rotational bias and angle accuracy. Participants from both conditions perform similarly in sketching the panorama. However, the results for the sketch maps reveal that participants in condition B were more accurate in terms of scaling and have lower direction of angular error (i.e., rotational bias) (see *Table 1*).

	Sketch Maps: M (SD)		Sketch Panoramas: M (SD)	
	Cond. A	Cond. B	Cond. A	Cond. B
SQRT of canonical organization (0 to 1)	0.44 (0.19)	0.31 (0.18)	0.47 (0.28)	0.43 (0.13)
Scaling bias	0.65 (0.04)	0.09 (0.05)	0.03 (0.03)	0.04 (0.04)
Distance accuracy (0 to 1)	0.81 (0.10)	0.8 (0.09)	0.89 (0.05)	0.86 (0.07)
Rotational bias in °	71.59 (49.93)	33.74 (30.36)	8.5 (10.27)	14.13 (7.76)
Angle accuracy (0 to 1)	0.64 (0.22)	0.77 (0.17)	0.86 (0.07)	0.84 (0.05)

Table 1. GMDA analysis results for sketch maps and sketch panoramas.

4. Discussion

RQ1 The results of the subjective measure (*Section 3.2.1*) indicate that there are no significant differences in term of helpfulness in locating oneself in the environment. However, our results from the objective measure (*Section 3.2.2*) suggest a different conclusion by indicating that the interactive map helps the participants to have a better sense of their environment. Therefore, even though the participants may not notice the help given by the interactive map, it seems that the interactive map has a positive influence on orientation.
RQ2 The self-reported helpfulness in locating the area (*Section 3.2.1*) is similar between 2 conditions. However, the evaluation of the open-ended question of listing out the visited AOIs (*Section 3.2.3*) and the sketched panorama

and map (*Section 3.2.4*) revealed that the subjects of condition B have a more accurate memorization. The better performance in condition B could be explained by two reasons: 1) participants in condition A have visited more AOIs and therefore had to memorize more places; and/or 2) condition B allows participants to obtain more related information of the place, which increases the amount of interaction and as a result helps them to better connect what they have heard and seen.

RQ3 Results in *Section 3.2.2* show that participants in condition B were more accurate in estimating the compass direction. Thus, the interactive map helps users to transfer the local position to a higher-level reference system. The difference can be explained by the fact that the amount of information exposed to the participants in condition B is more than that in A.

5. Conclusion and Outlook

We have introduced Map-Enhanced GAIN-LBS which combine three communication modes – gaze, audio, maps – to assist tourists in identifying features in the panorama and in orientation. The between-subject study demonstrated that for a tourist it is easier to orient when she has an interactive map to work with, and that she can remember more information about the views. The added value of a map without interaction to the normal GAIN-LBS was not tested. As a next step, we plan to integrate mechanisms of gaze-guidance and narrative generation (Kwok et al., 2019) with Map-Enhanced GAIN-LBS.

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