Mobile Map Interaction - Evaluation in an indoor scenario

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Abstract: Providing indoor navigation within a building is usually associated with large investments in infrastructure. We present and evaluate an approach to provide indoor navigation with minimal infrastructure investments. In our approach people use a mobile camera device like a mobile phone as a magic lens. When the device is sweeped over a map of the building, the way is augmented on the camera image of the map. We show that people using our system use more maps and make less errors. The main advantage of our approach is that no tracking of the user is needed - the navigation is solely based on the user's mobile phone and paper maps.

1 Introduction

Everyone can remember a situation when he entered an unfamiliar building looking for a certain person. Probably the room number is known, but the unstandardized building plans are difficult to read. The signs pointing to certain departments are difficult to interpret, and many people fall back to social navigation and ask someone. But if the building is big, it is improbable that the person asked knows the way. In the scenario we propose the first action upon entering the building would be to take one's mobile phone and point it to the next building map. It would be possible to select the person one is looking for from a list or a poster with the employees' photos. The way to the selected person would then be displayed on the camera image of the buildings' map. If maps are provided at all decision points within the building, the correct way would always be available. To evaluate our approach we implemented a prototype of the system on an OQO [1] and tested the prototype with users of different familarity levels with the building.

2 Related Work

The system presented in this paper is based on our previous work on augmenting digital information on paper based maps [1]. The magic lens approach we implemented is presented in [4]. In order to track the camera device in map coordinates, we use an optical

[1] www.oqo.com

marker based tracking approach [2, 3]. The marker-based approach requires printed markers on the physical map, which need to be visible in the camera image. This approach is very robust and has the main advantage that no special infrastructure is needed. Reily [5] uses physical maps equipped with RFID tags to provide additional information on a mobile device, which means that a RFID reader is needed on the mobile device.

3 Implementation and Interaction Schema

The prototype is implemented in Java and runs on an OQO. We installed an USB camera on the back of the OQO to simulate a mobile phone with a camera. The camera image is superimposed with the path and directions the user needs to take. The user can interact with the application with a pen.

The user can select persons he wants to visit from a list. When the device is pointed to a map the current location of the user is highlighted with a red dot. Note that, because the location of the map is encoded in the marker, no additional localization technology is needed. In addition, the path from the current position to the goal is augmented on the map. The device can be sweeped, tilted and turned freely over the map. Zooming is natural by moving the device towards and away from the map (see Figure 1).

Figure 1: Usage of the mobile camera device.

4 Evaluation

4.1 Test Scenario

The evaluation took place in the building of the institute for geoinformatics in Münster. We recruited 25 participants at the age of 19-27 for the study (21 men, 4 women), most of them students of Münster University. We divided the participants into 3 categories depending on their spatial familiarity with the building: Beginner, Medium, and Expert. Beginners were not familiar with the building and visited it for the first time for the purpose of this study, most of them were students from other departments. Medium users already knew parts of the building and were mostly students from our department towards the end of their first year. Experts were familiar with all floors and most parts of the building. This group consisted mainly of master students in their last year from our department. The test was carried out with a group equipped with a mobile camera device (12 users: 4 Beginners, 4 Medium, 4 Experts) and a control group (13 users: 4 Beginners, 4 Medium, 5 Experts) which had no such device available.

4.2 Test Setup

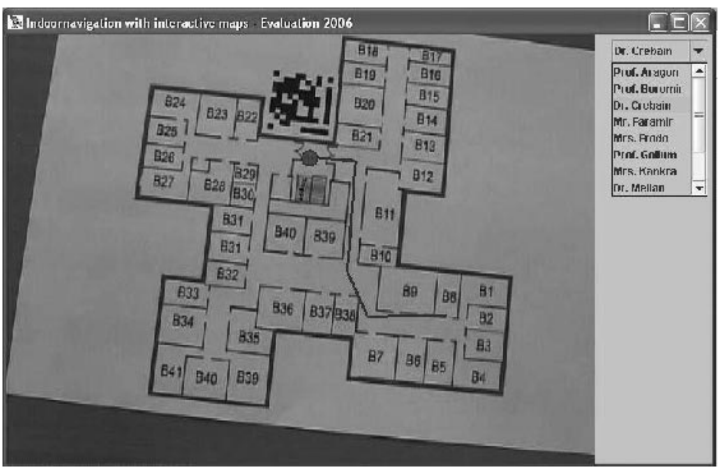

Figure 2: Screenshot of the application.

The starting point for all users was our lab. The goal for all participants was to find the way to the room of the fictive faculty member Mr. Smeagol. To reach the destination they had to travel through two floors. Along this way four paper based map have been attached to the walls nearby critical decision points. In order to allow easy identification the maps were marked with a blue iconic information sign (see Figure 1). The current location was marked on the map with a red dot ("You are here"). Both participant groups could use these maps to orient themselves in the building. Of course the usage pattern for the group with the mobile camera device differed from the patterns of the control group.

4.2.1 Mobile camera device group

At the start point of the navigation users were briefly introduced to the application running on the mobile camera device. Users had to select the name of the target person from a list (see Figure 2). Afterwards they were told, that at each of the four maps in the building, the mobile camera device could provide them with a map overlay showing the way from the current location to the target destination. During the navigation task users were free in using the camera device with the maps (see Figure 1). In case of a navigation error, i.e. when users took a wrong turn, the experimenter interacted and put the user back on the right path.

4.2.2 Control group

Users without the devices received a list with persons and their associated rooms at the laboratory. Since they had no visualization of the path, they had to infer that information from the maps alone. Navigation errors were handled in exactly the same way as discussed in the previous section.

4.2.3 Variables

The independent variables of this evaluation were the technology type (mobile camera device versus no device) and the spatial familiarity (Beginner, Medium, Expert). The dependent variables were the time needed, the number of accessed maps, and the number of errors. Time was measured from the first view on the map to the arrival at the destination.

5 Results

On average all users needed 158 seconds to complete the wayfinding task from the lab to Mr. Smeagol's office, they made 1.4 mistakes and used on average approx. 3 maps (out of 4). The average orientation time was similar for both groups, but the variability of orientation time for the camera device group was clearly higher. Presumably this effect was caused by the different level of familiarity to this type of mobile device (although we have not asked participants explicitly about this). The control group made significantly more errors on average (t-Test, $p < 0.05$) and the variability of the error rate was much higher than in the group with the mobile camera device. The group of mobile camera device users was able to lower the number of errors by about 60% (see Figure 5). Also the number of maps used was by 25% significantly higher ($p < 0.05$) in the camera device group than in the control group (see Figure 4). Since earlier studies with indoor maps have

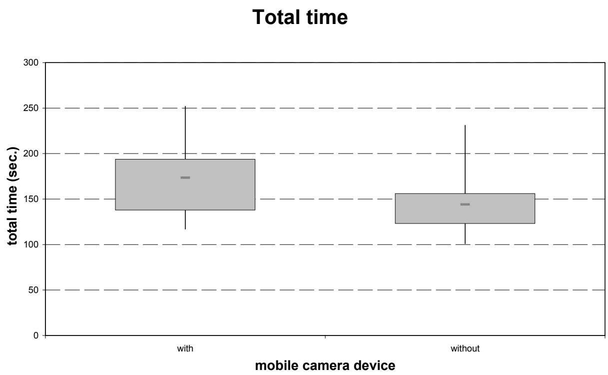

Figure 3: Comparison of the total wayfinding time between users with and without a mobile camera device. The graphs show box plots with mean value, 25% and 75% quartiles, and min/max values.

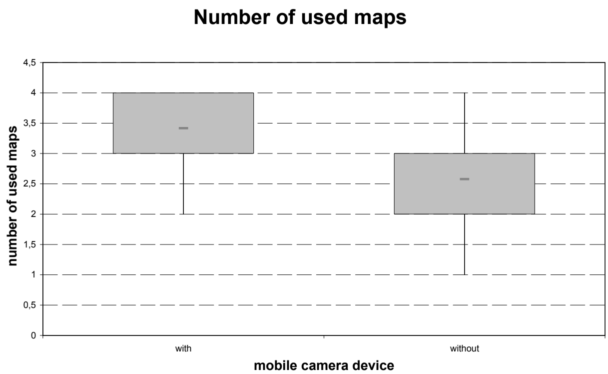

Figure 4: Comparison of map usage of users with and without a mobile camera device. The graphs show box plots with mean value, 25% and 75% quartiles, and min/max values.

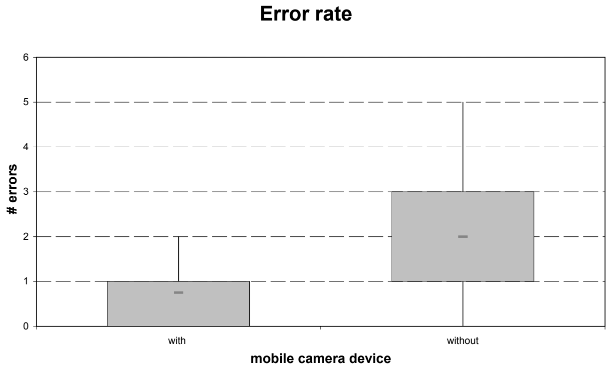

Figure 5: Comparison of the error rates between users with and without a mobile camera device. The graphs show box plots with mean value, 25% and 75% quartiles, and min/max values.

indicated that users have problems with schematic indoor maps in general [6], this problem might be reduced when providing dynamic map overlays with concrete way instructions.

It was slightly surprising that the control group was on average 10 seconds faster (although not significant) than the device group (see Figure 3). One possible reason could be the fewer maps used by the control group and that errors had no big influence on the overall wayfinding time (since users were interrupted and put back on the right track). Not very surprisingly spatial familiarity had a clear effect on the number of errors. The higher the spatial familiarity was the lower the amount of errors during the wayfinding task (see Figure 6). When looking at the data for Beginner users in the camera device group, it is interesting to note that they made approx. the same amount of errors as the Medium users of the control group. A similar relationship exists between the Medium users of the camera device group and the Expert users of the control group.

6 Summary and future work

In this paper we have presented the results of a preliminary user study looking at the effects of a navigation system that uses paper based maps and a mobile camera device overlay. The results show that using such a dynamic overlay increases navigation performance by reducing navigation errors. Most of our interpretations are still speculative, but we believe that this study gives a first idea of the usefulness of such a simple indoor navigation system based on mobile camera device.

We plan to extend our studies to outdoor scenarios and will take into account the effect

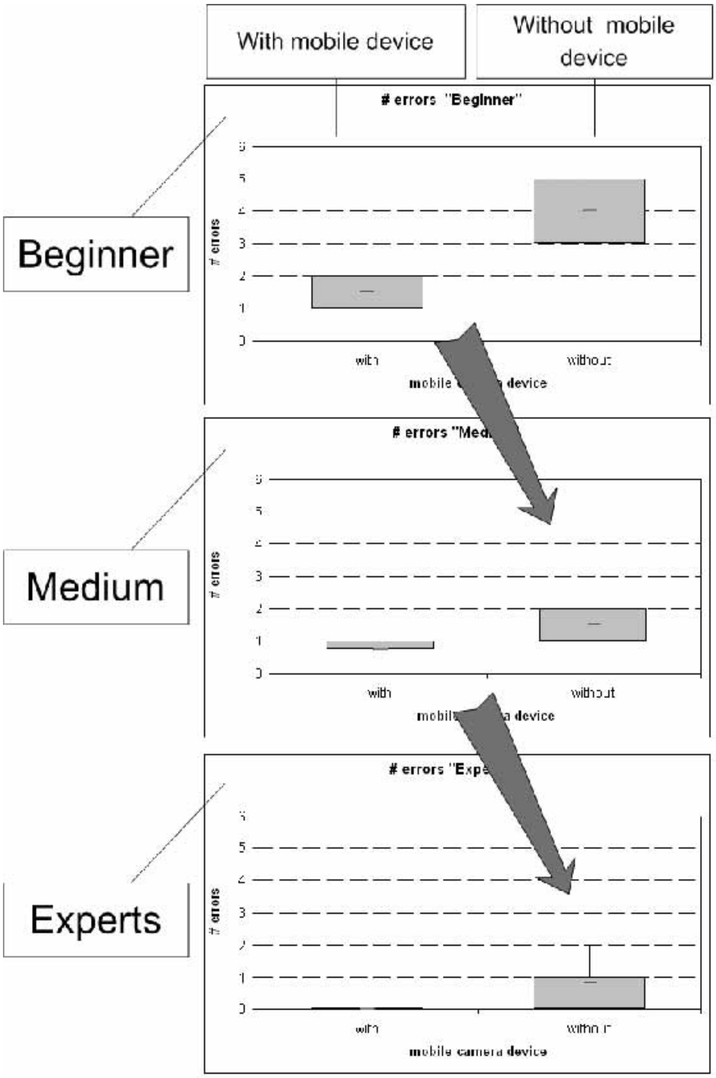

Figure 6: Comparison of spatial familiarity classes and error rates. The graphs show box plots with mean value, 25% and 75% quartiles, and min/max values.

of the familiarity with the mobile device. In the presented experiments wayfinding time could not be used to measure navigation performance since errors had no influence on it. We will try to redesign the experiments in a way that wayfinding time would gain more expressiveness. Finally we are planning to transfer our results to outdoor navigation scenarios (mainly with city overview maps) and would like to carry out another user study with a more complex navigation task involving more maps. As we said, the main advantage of our approach is that no tracking infrastructure is needed, and we believe that the cheap and easy installation at sites makes our approach very promising.

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