CO-074

THE IMPACT OF DIFFERENT PRESENTATION FORMS ON THE EFFICIENCY OF SUPPORTING PEDESTRIAN WAYFINDING

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Because of a lack of navigation solutions, tasks like route planning or wayfinding are still mostly done by using traditional means of orientation (e.g. paper maps), asking the way or simple intuition. Even guidance systems for public transport, such as electronic time tables or info terminals, sidewalks are only considered marginally. In effect there are deficits in the mobility chain, especially in terms of wayfinding for distances which can be easily covered by foot. This fact applies to the "last mile" from where one left public transport to actually reaching the point of destination.

In this paper selected results of a study on how the information deficit of pedestrians can be closed effectively with novel navigation technologies. A joined project called "ways2navigate" aims at increasing the degree of usability (for individual wayfinding) and personalisation of pedestrian navigation systems for daily life, especially in urban settings. In order to reach this goal ways2navigate studies different navigation concepts from which essential technological conditions and target group specific parameters for future pedestrian navigation solutions are derived. The project investigates the suitability of language and Augmented Reality-based navigation concepts in comparison to digital maps for transmitting navigation and route information to pedestrians. These technologies (digital maps, language and Augmented Reality) are tested with the help of a scientifically proven metric both quantitatively and qualitatively. The approach is evaluated on the basis of test routes in a pilot region in the city of Salzburg in three iterative experiments with 20 test persons each. The results contribute to a knowledge base which deals with the question under which conditions and for which target groups a deployment of the afore mentioned technologies is meaningful in navigation systems.

1 INTRODUCTION

Navigation systems, including those for pedestrians, are becoming increasingly popular. Usually, mobile devices - such as mobile phones, pocket computers or similar compact equipment - are used as hardware platforms. These devices can be characterized by the fact, that the size of the display is usually small, as a result of keeping the device as compact as possible.

Maps are important presentation forms for routes and topographic features and, therefore, usually central parts of all kinds of navigation systems (Gartner et al 2001). Characteristic attributes of maps are the scale and the graphical code used. It is of key importance that a balanced combination of scale, perceivable graphical coding and selected content is aimed at when attempting to represent the topography or a spatial scenario for a particular purpose. This balanced combination has to be applied on a media which transports the map, whether it be paper, the screen of a computer, or a mobile device. The size of the media plays an important role for this balance as well as the overall content and structure of maps.

Different sizes of maps have always been used. The size used is usually correlated with the purpose of the map. When using maps for navigation purposes and orientation in real world the conflict between representation of a relevant part of space (in terms of keeping the overview) and an "easy-to-use" format has led to various solutions in the past, including especially different forms of folding or the use of different scales.

When using electronic devices and screen displays the media not only allows the display of static representations but also of interactive applications. Scrolling, panning and zooming are usually used for changing the view on a map or even selecting a different map (with a different context of scale, graphical coding and content), when needed. Although these tools enable the user to access all parts of a map, the overall context of a map of a particular scale is not accessible at once, if this map is exceeding the display of a particular device in size.

In this paper we address the influence of display size on spatial knowledge acquisition, especially in the context of orientation and navigation. Our hypothesis states that the acquisition of spatial knowledge and therefore the ability to orientate in real world is influenced by the size of the display on which maps are presented.

2 SPATIAL COGNITION AND WAYFINDING

Questions related to pedestrian navigation systems are currently tackled by various disciplines, including computer science, cognitive science, geoinformation sciences, communication science as well as modern cartography. The analysis of relevant work on human acquisition of spatial knowledge and human orientation marked the starting point of our research.

Issues of spatial cognition can basically be classified in two categories, the egocentric and the exocentric strategy of spatial cognition. Theories on egocentric spatial cognition deal with aspects of how humans are able to reconstruct a three-dimensional model from the two-dimensional image recorded by the eye. It is stated that three core directions are applied from an egocentric perspective (the vertical body axis for distinguishing above and below, the horizontal body axis for distinguishing behind and in front of and another horizontal body axis in 90° distance for distinguishing left and right (Schweizer et al 2006, Herrmann et al 1998). Navigation instructions usually deal with the exocentric spatial cognition, where a point in space is used as origin from where the directions are given (Schweizer 1997). Instructions about directions refer to objects in space, which can be used to define and describe directions. Such objects are called landmarks and can be identified by outstanding attributes (Sorrows & Hirtle 1999). A distinction between local and global landmarks is useful in the context of orientation, as local landmarks are used for local decisions or confirmations (such as "turn right at the green building"), while global landmarks can be referred to from a bigger area. As Mallot (2000, 2004) has demonstrated, humans are able to adapt their orientation strategies if either only local or global landmarks are available. If a person is offered both landmarks types as reference objects, local landmarks play a more important role for orientation.

The strength of human wayfinding strategies lies in the ability to integrate different strategies, like referring to global and local landmarks or using integrative semantic descriptions or route based instructions (Mallot 2004).

The term cognitive or mental map, which was introduced by authors like Lynch (1960) or Downs and Stea (1973), is referring to the result of the process of spatial knowledge acquisition. Generally speaking, three distinct functions of mental maps can be defined as (a) spatial recognition and identification, (b) spatial localization and memory, and (c) planning of spatial actions (Poucet, 1993). Helwich (2003) pointed out that mental representations are primarily topological descriptions of spatial relations, while Lynch (1960) distinguished five elements of mental maps as lines, borders, areas, nodes and landmarks. Based on these elements a mental map is structured as the result of individual combinations. Appleyard (1970) built empirical tests upon this theory, which confirm in general Lynch's theory but developed a further distinction by categorizing sequential (lines, nodes) from spatial elements (borders, areas, landmarks).

Mental maps of cognitive representations of space are referred to when humans have to act in space, e.g. find a way (Kuipers 1982). Tversky (1993) pointed out that humans are referring to various mental maps with different "scales" and "abstraction levels". For solving a spatial problem or acting in space, a human is dependent on the availability of information about "where", which includes the own location as well as the location of other relevant objects (target, decision points), as Downs and Stea (1973) have mentioned. They argue further, that beneath information about "where" information about "what" is essential as well. Focusing on way finding this means that the information needed includes such on general orientation, route decision, route confirmation and goal finding (Downs & Stea 1973). General orientation means the relevant information, which is needed to answer the question "where am I". Therefore elements of the stored mental map have to be connected to perceived elements of the real world. If successful, this will allow defining one's current location as the origin of the egocentric spatial reference system. The connection of cognitive representations with elements of the real world is done via reference points. Such reference points can be global or local landmarks or other significant objects. Gartner et al (2005) have argued that relations of humans to particular objects can be used in this context as well. Route decision is the strategy that humans develop in order to find a connection between a start point and an end point. Therefore sequences beneath decision points are planned. When moving, this plan is monitored permanently by referring to objects of the real world and comparing them with the cognitive representation for route confirmation. Finally the relevance of mental maps for way finding can also be found in the identification of the target as such, the goal finding.

Spatial knowledge acquisition is needed to build mental representations which can be referred to for way finding. As Platzer (2005) and also Briggs (1973) pointed out, various methods of spatial knowledge acquisition can be used, including the sensual perception of the real world as well as the acquisition of spatial knowledge from models of the real world, such as maps. Another common way of building cognitive representations is the derivation of experiences from comparable situations. In this context Neisser (1976) and Downs and Stea (1973) pointed out that the active knowledge acquisition by human senses when moving through real space is resulting in more and better information. Whitaker & Whitaker (1972) mentioned, that personal characteristics have a big influence on spatial knowledge acquisition.

When analysing mental maps, the method of sketching maps is often used. As mentioned by Golledge (1976) and Platzer (2005) the interpretation of sketch maps have to take into account many influences, most of them dealing with abilities and personal skills of test persons. Byrne (1979) demonstrated this influence in a test, where 90% of angles of crossings between 60-70° and 110-120° have been drawn as ninety degree angles in sketch maps. Tversky (1981) and Thorndyke et al (1982) pointed out that the skills of drawing correct angles and finding a way are not significantly correlated. It is therefore useful to stick to topological interpretation of sketch maps only, as Lynch (1960) already mentioned, but enhance the possible results by additional methods of estimating distance or direction, such as pointing methods (Henry 1992, Popp 1998).

Research on the influence on various presentation forms on wayfinding (Radoczky 2003, Dillemuth 2007), on the usage of automated navigation systems (Parush et al 2007), and on the influence of the size of displays (Dillemuth 2007) have demonstrated, that the focus is going beyond technical questions when developing navigation systems. These findings are are used as a fundament for this research.

3 METHODOLOGY

Way2navigate is a research project of TU Wien, Salzburg Research and another 3 institutes. It investigates the suitability of language and Augmented Reality (AR) based navigation concepts in comparison to digital maps for conveying navigation and route information to pedestrians. These technologies are tested with the help of a scientifically proven metric both quantitatively and qualitatively in three iterative experiments. Spatial knowledge acquisition is needed to build mental representations, which can be referred to for wayfinding and other spatial tasks. In order to gain an in-depth understanding of the effectiveness of different presentation forms in guiding pedestrians, how these presentation forms influence the acquisition of spatial knowledge should be carefully investigated. This paper reports the results of the first experiment, with the focus on comparison of spatial knowledge acquisition with different presentation forms (Digital map, Language, and AR).

The overall research goal is to investigate differences in spatial knowledge acquisition with different presentation forms, comparing digital map, augmented reality (AR), and language (enriched with landmarks and semantic information) in the context of GPS-based pedestrian navigation.

The Hypothesis can be formulated like this: In the context of GPS-based pedestrian navigation, the presentation form digital map results in better spatial knowledge acquisition compared to language and AR, reflected by:

- higher accuracy in spatial tasks of pointing directions
- higher accuracy in the topology of sketch maps
- higher accuracy in identifying the half of the route

Based on the above hypothesis, an empirical test has been set up. A route in the city centre of Salzburg (Austria) was selected. The route was divided into three sub-routes, with each including a number of waypoints. The test was performed with 24 persons, which were also divided into three groups. For each sub-route, these three groups each used one of the presentation forms (digital map, AR, and language). When they reached the next sub-route, they used another presentation forms. The whole test can be completed within 2 hours.

The test setting included an instruction phase by the instructor, where the test conditions were explained. During their navigation, test persons were observed by the instructor, and their movement and interaction with the navigation system were recorded by a logger. When reaching the end of each sub-route, test persons were asked to solve some tasks and answer some questions:

1. To give an approximate direction to the starting point: measured in angle
2. To draw a sketch map of the area they just passed as precisely as possible: focusing on the route and landmarks
3. To mark the half of the route on the sketched map
4. Familiarity with the sub-route.

4 RESULTS

The analysis of the results focuses on the sense of direction (the pointing task), sketch maps (focusing on topological aspects: sketched landmarks, missing/wrong/unnecessary turns), and sense of distance (marking half of the route). We only consider the results from participants who are unfamiliar with the sub-routes. In the following, we present and discuss the results.

- Sketched landmarks

Figure 1 show that test persons with the “Language” application drew more landmarks in their sketch map compared to test persons using “AR” and “Digital map”. We also found that 78% of the landmarks sketched by persons using “Language” are mentioned/included in the audio wayfinding instruction.

The reason why test persons using “Digital map” and “AR” drew fewer landmarks is that for both applications, landmarks are not explicitly highlighted (for digital map, landmarks are displayed in background map, while for AR, landmarks are not visualized). For the “Language” application, landmarks are explicitly included in the wayfinding instruction.

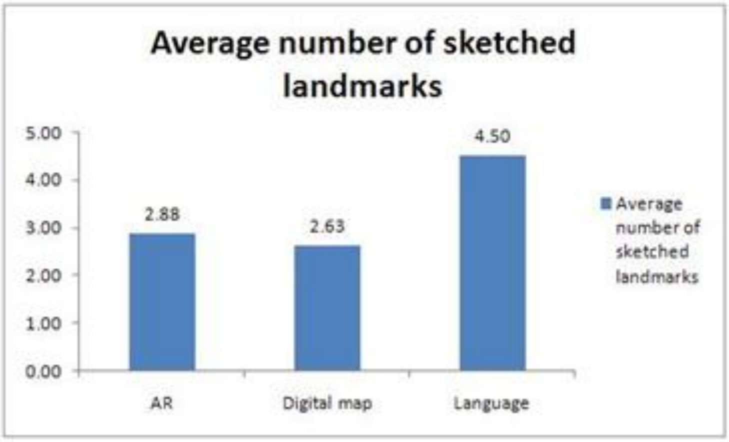

Figure 1. How the number of sketched landmarks differs among using different technologies

- Missing/wrong turns in sketch map

The results in Figure 2 show that test persons using “Digital map” made considerably fewer errors in sketching turns compared to test persons using “AR” and “Language”. This is consistent with our expectation: in the “AR” and “Language” application, turns are not conveyed/presented in a spatial-related overview context.

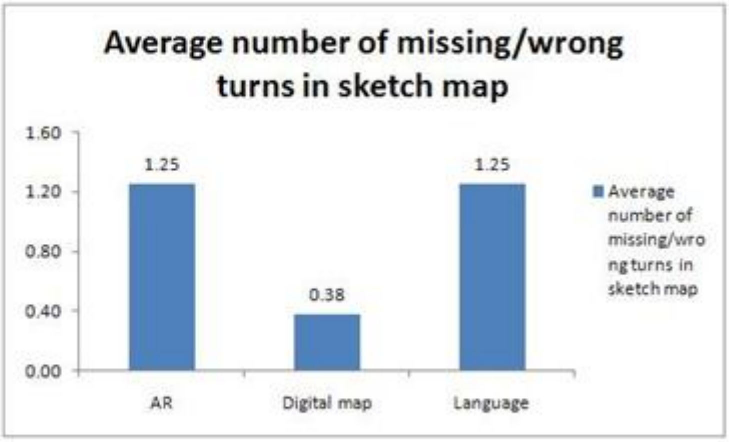

Figure 2. How the number of missing/wrong turns differs among different technologies

- Sense of distance (marking the half of the sub-route)

Figure 3 shows that test persons using “Digital map” performed better in marking the half of the sub-route compared to test persons using “AR” and “Language”. However, the differences among them are not significant as our expectation. An explanation may be that test persons using “Digital map” did not make full use of the “Digital map” application (e.g., they seldom used the “overview map” function). As a result, for all three presentation forms, the knowledge about sense of distance is mainly gained from sensual perception of the real world (without the acquisition of spatial knowledge from presentation forms, such as digital map).

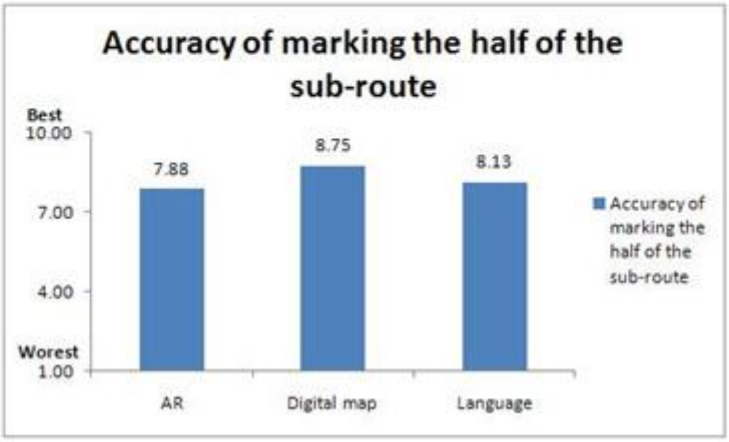

Figure 3. How the sense of distance differs among different technologies

-Sense of direction (Pointing to the starting point)

The results in Figure 4 show that test persons using "Digital map" and "Language" performed considerably better in marking the half of the sub-route compared to test persons using "AR". The results for "AR" are not surprised, because the "AR" application suffers from the poor GPS signal (compared to "Digital map" and "Language"), and thus brings some confusion to the test persons. However, test persons using "Digital map" did not perform considerably better than test persons using "Language", which is inconsistent with our expectation. A possible explanation is that test persons using "Digital map" did not make full use of the "Digital map" application (e.g., they seldom used the "overview map" function).

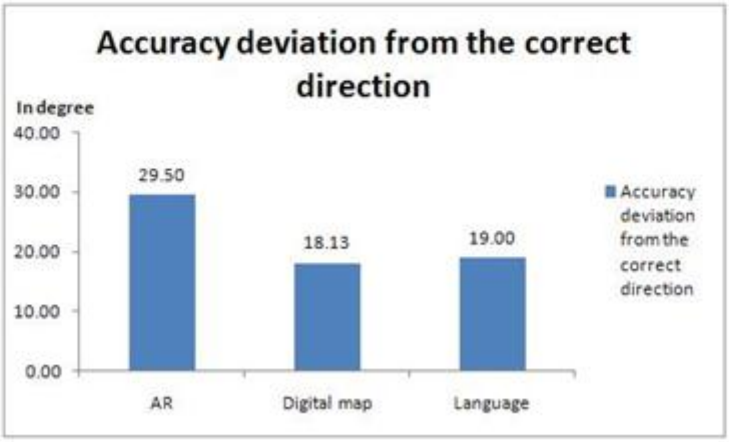

Figure 4. How the sense of direction (Pointing to the starting point) differs among different technologies

5 DISCUSSION OF RESULTS

In summary, the results confirm our hypothesis that in the context of GPS-based pedestrian navigation, using the presentation form "digital map" leads to more accuracy in pointing the starting point, more accuracy in sketched landmarks, and more accuracy in marking the half of the route.

However, as landmarks are not explicitly highlighted in both the "Digital map" and "AR" applications, the results for sketched landmarks cannot really be used to prove/disprove the hypothesis on the aspect of sketched landmarks.

The following limitations about the above results have to be noted:

1) In total, only 24 person/sub-route pairs are labeled as "unfamiliar"

2) Marking half of the sub-route: for most of the test person, their marks of the half were somehow consistent with the half of the route in their sketch map

3) Measuring the pointing direction: accuracy of the Compass

Currently, we are improving the applications ("Digital map", "Language" and "AR") and the methodology for the second experiment. We also plan to differentiate three kinds of spatial knowledge (landmark, route, and survey knowledge), and investigate how these presentation forms influence the acquisition of these three spatial knowledge.

6 CONCLUSION AND OUTLOOK

Navigation systems on mobile devices have become increasingly popular. Usually mobile devices can be characterized as having small displays, restricting the possible area and size of displayed maps. This has a strong influence on spatial data acquisition and thus on the ability to orientate and navigate in real world, as has been shown in this paper. More research is necessary on the influence on different presentation media in correlation with different display sizes.

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