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12 Geo-Identification and Pedestrian Navigation with Geo-Mobile Applications: How Do Users Proceed?

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Abstract

Geo-identification and pedestrian navigation with the use of geo-mobile applications requires a multi source interaction of the users with the environment, the (carto)graphic interface and their mental maps. This interaction is not effectively supported by current implementations that are mostly geared to vehicle navigation. The aim of the research presented in this paper was to look through the ways in which people navigate and orientate themselves in unfamiliar cities or areas supported by mobile map interfaces. In this regard, an experiment with real users and tasks was established in two areas in Amsterdam, based on a research methodology involving a questionnaire, thinking aloud with audio/visual observation and synchronous screen logging and a semi-structured interview. Use was made of a special technical solution that reduces the resources needed for field-based studies and allows for better analysis of the results. The findings of the experiment show the importance of particular landmark types and GPS-independent automatic map orientation for geo-identification and navigation and support further field-based studies on smooth zooming techniques. The research methodology worked well and could be applied to future experiments in order to gain more insight in the mobile users' interactions in real contexts.

Keywords: geo-identification, landmarks, mental maps, smooth zooming, user research methodology

12.1 Introduction

The ever increasing mobility of people pushes the need for effective tools supporting their geographical orientation and navigation. In addition, the wide availability of mobile devices, such as smartphones and PDAs and their capabilities to serve users as a better digital and interactive alternative to paper maps, has opened up an improved potential for mobile orientation and navigation, as well as location based services. There are already a lot of geo-mobile applications with (carto)graphic interfaces available. However, most of them are dedicated to car navigation and are not suitable, for instance, for use by pedestrians. This is not only because of the database contents of such navigation systems, but also because their interface and presentation aspects do not seem to support very well the user's orientation or personal geo-identification. For example, in newspapers we sometimes come across hilarious examples of people who do not know at all where they are after their car navigation system stopped functioning. Therefore, more research is needed in order to make geo-mobile applications a better successor of paper maps, which are still convenient all-round tools for orientation and navigation to many people (Hampe & Elias 2004).

This paper reports on an experiment executed with users (pedestrians) who pay a visit to a city area that is unknown to them and who want to navigate and orientate themselves with two geo-mobile applications that are already on the market. The objective of our research was not to evaluate these existing applications, but to learn more about the ways in which people navigate and orientate themselves with the help of supporting tools with a cartographic interface. As such, this experiment is part of two more extensive research projects in which the authors are involved: PhD research on the usability of geo-mobile applications and a government funded Dutch research project on *Usable (and Well-scaled) Mobile Maps for Consumers* (UWSM2) (URL 1). The PhD research should lead to the prototyping and evaluation of a new and more usable geo-mobile application. To this end a User-Centred Design approach is followed and the experiment reported in this paper can be considered as part of the requirement analysis stage. The UWSM2 project focuses on the development of generalization solutions for mobile maps. This is not only to possibly allow progressive wireless data transfer, but also because zooming in and out is a way of interaction that is required for orientation and navigation. Therefore, in our experiment, specific attention has been paid to this latter requirement.

This paper starts with a brief sketch of the theoretical background of the experiment and the research questions addressed in it. Thereafter, the set-up of the user research and the methodology are discussed. In a separate section specific attention will be devoted to the technical solutions to the desire to obtain synchronous user observation, mobile screen logging and thinking aloud research data for easy analysis later on. The results of the experiment and their analysis constitute the last and major part of the paper before the conclusion.

12.2 Personal Geo-Identification in an Unfamiliar Area

When using geo-mobile applications, visitors to unfamiliar areas interact with information coming from different sources in order to geo-identify (orientate) themselves and navigate. *Personal geo-identification* is the understanding of "where am I?" in geographic space in terms of a mentally translated and identified personal location in the real world. In case of mobile map users, the main information sources are the environment, the representation thereof in terms of (carto)graphics on the interface of the mobile device and the mental maps of the users. In *Figure 12.1*, a pedestrian user of a geo-mobile application who is trying to geo-identify himself is shown. The interaction with the three available information sources can lead to confusion, and as a result, the user can have difficulties in finding proper answers to his geospatial questions.

Imagine a person visiting an unfamiliar city and leaving an underground railway station through one of many exits. Such a visitor may not immediately know where exactly s/he is. But understanding "where am I?" is a necessary very first step before finding solutions to follow-up spatial problems such as in which direction s/he should move in order to reach a particular destination. Several types of *landmarks* and other structural elements may act as common points between the virtual and real worlds available to mobile map users. The importance of landmarks as orientation, navigation and wayfinding aid for this type of users has been reported in many earlier studies (Golledge 1996, Michon & Denis 2001, Millonig & Schechtner

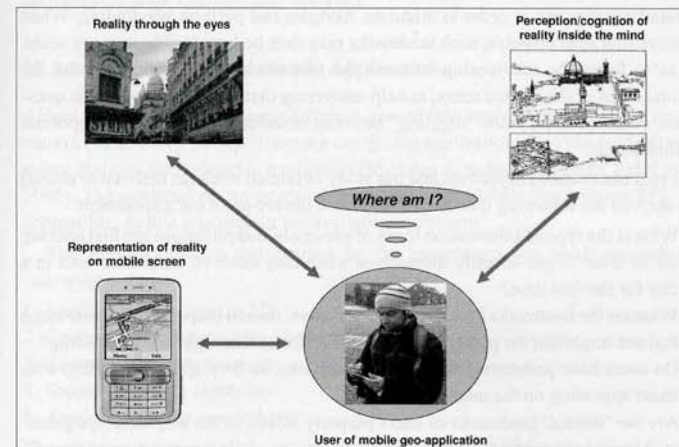


Fig. 12.1. Personal geo-identification through interaction with three different sources.

2005, Sorrows & Hirtle 1999) and has lead to different interesting new ideas, such as active landmarks (Gartner & Radoczky 2007).

In combination with landmarks, and due to the limitations of mobile displays (e.g. screen size and resolution), users frequently use zooming and panning functions of the mobile map in order to have both overview and detailed information about the area that they are (moving) in. The problem is that overview maps lack a lot of information in order to not overload the screen and make the map display illegible, while at the same time zoomed-in views lack the global angle of overviews, one of the main reasons why maps are made (Yammiyavar et al. 2007, Büring et al. 2006). Unfortunately, the change of scale of the mobile map can jeopardize the mental connection between the users' mental maps, the environment and its map representation, leading to disorientation and spatial confusion. In order to deal with this problem, the use of so-called smooth and/or animated zooming, instead of zooming in discrete steps or scale levels, is currently under investigation, for example in our UWSM2 project referred to above (also see Hornbaek et al. 2002, Midtbo & Norvik 2007). Because landmarks are strongly supporting orientation, navigation and wayfinding processes they should be visible in all the used scales so that they support the mental map connection between the real and virtual geographic worlds. Memorization of landmarks and their surrounding less prominent objects is a usual technique that the human mind is often using in order to keep that connection (Harrower & Sheesly 2005, Midtbo & Norvik 2007).

One of the aspects we wanted to investigate in our user experiment is what are the landmarks that users of mobile geo-applications and in particular visitors to unfamiliar cities use in order to orientate, navigate and perform wayfinding. When generalizing map displays, such landmarks may then be kept visible in every scale, so as to foster the relationship between the real world, the mobile map and the mental maps of the mobile users, to help answering their possible geographic questions, even when they are "togglng" between obtaining overview and important spatial details.

From our research objectives and our study of related work (as referred to above) we derived the following questions that guided the set-up of our experiment:

- What is the type of information users of geo-mobile applications are first seeking for in order to geo-identify themselves when they enter an unfamiliar area in a city for the first time?
- What are the landmarks existing in both the users' mental maps and in mobile maps that are important for personal geo-identification and navigation/wayfinding?
- Do users have problems with linking landmarks, as they appear in reality, with those appearing on the map display?
- Are the 'mental' landmarks of users properly linked to the map displays generated by the geo-mobile applications?
- In which ways do users use landmarks when they try to orientate themselves?

- How often and when are users confused about their location and what is the reason for that?
- When users know where they are, do they still make mistakes in deciding which direction to take in order to navigate to a destination? If so, what are the reasons for that?
- Do users benefit from the use of smooth zooming techniques in mobile maps rather than step-wise zooming?
- Do users benefit from 3D map and landmark representations?

12.3 The Experiment

12.3.1 Explorative Research

In answering the research questions listed above it was not the intention to obtain statistically valid quantitative results, nor was it the intention to evaluate the geo-mobile applications used. The objective of the field-based experiment we developed was to provide information about user requirements for personal geo-identification and pedestrian navigation that may be used for future prototype design. For our experiment, two existing geo-mobile applications with different characteristics were selected in order to be used by a group of test persons to perform real world tasks, related to personal orientation and navigation in the context of a visitor to an unfamiliar city. The test persons were observed and their thoughts, behaviour and performance were recorded and analyzed.

12.3.2 Selection of Geo-Mobile Applications

Although today there are many different geo-mobile applications available on the market (*Table 12.1*), most of them are navigation applications for vehicles with only minor abilities for pedestrian navigation (Millonig & Schechtner 2005, Rehl et al. 2005). The applications investigated were Windows Mobile Smartphone/PPC v.6 compatible, as this was used in the available equipment.

The selection of two applications for the experiment was made through the following criteria:

1. Landmarks presented in 3D
2. Coverage of the study area (Amsterdam)
3. Zooming/panning functions
4. Smooth zooming capability
5. Availability to the researchers

The application that met all the criteria was iGo My way v. 8.0 (*Figure 12.2a*). Google (mobile) Maps (*Figure 12.2b*) was selected for comparison reasons: it does not offer

smooth/animated zooming functionalities and no landmarks on the map display, but we expect that this application will gain a wide distribution in the near future.

Table 12.1. Examples of existing (Windows Mobile 6.0 compatible) geo-mobile applications (numbers refer to the criteria explained in the text).

Web link	Application	1	2	3	4	5
URL 2	agis Navigator	N	N	Y	N	N
URL 3	Alturion GPS Professional v.6.0	N	Y	Y	N	Y
URL 4	amAze v.4.2	N	Y	Y	N	Y
URL 5	Co-Pilot Live v.7.0	N	Y	Y	N	Y
URL 6	Destinator 7	N	Y	Y	N	Y
URL 7	Google (mobile) Maps	N	Y	Y	N	Y
URL 8	Google Navigator v.3.6	N	Y	Y	N	Y
URL 9	iGo My way 2006 plus	N	Y	Y	N	Y
URL 10	iGo My way v.8.0	Y	Y	Y	Y	Y
URL 11	INAV I-Guidance v.4.0	N	N	Y	N	Y
URL 12	Intellinav v.2.0	N	N	Y	N	N
URL 13	Maptech Memory Map v.5.0	N	Y	Y	N	N
URL 14	Marco Polo Mobile Navigator 3	N	Y	Y	N	Y
URL 15	MioMap v.3.2	N	Y	Y	N	Y
URL 16	MioMap 2008	Y	Y	Y	Y	N
URL 17	Navigon Mobile Navigator v.6.0	N	Y	Y	N	Y
URL 18	Nokia Maps (Smart2Go)	N	Y	Y	N	Y
URL 19	Odyssey Mobile 4	N	N	Y	N	N
URL 20	OnCourse Navigator v.6.0 Plus	N	Y	Y	Y	N
URL 21	Pharos Ostia	N	Y	Y	N	N
URL 22	PocketMap Navigator (USA)	N	N	Y	N	N
URL 23	PocketWAW v.3.0	N	N/A	Y	N	Y
URL 24	Route 66 Navigate 7 PPC	N	Y	Y	N	Y
URL 25	Teletype GPS	N	Y	Y	N	N
URL 26	Tom Tom Navigator 6	N	N	Y	N	Y
URL 27	Via Michelin	N	Y	Y	N	N

12.3.3 Test Persons

In order to perform the experiment we were looking for a specific type of user representing a visitor to an unfamiliar city using a geo-mobile application. This visitor is “dropped” at a location unknown to him/her and is supported by the information provided by the mobile interface. Suitable test persons would not have to be deterred by using a mobile application and the selected age range was from 20 to 60 years old. They could have different levels of knowledge in terms of (mobile) maps, use of mobile devices, cartography and orientation and navigation techniques and abilities. The 8 test persons that took part in the experiment were recruited from MSC and PhD students of ITC (the International Institute for Geo-Information Science and Earth Observation). It is true that, compared to ordinary tourists, they may have



Fig. 12.2. iGo My way v. 8.0 (a) and Google Maps (b) showing the same region of Amsterdam in 3D and 2D respectively.

a more than average affinity with maps and geo-mobile applications, but they do not originate from the Netherlands and were not familiar with the study area. They felt attracted to Amsterdam and free transport to this city was the stimulus for them to participate in the experiment.

12.3.4 User Profiles

Five male and 3 female test persons participated in the experiments, with their age ranging from 24 to 47 years old. They had different countries of origin. The general profiles of the participants are shown in *Table 12.2* and their background in fields related to this research in *Table 12.3*.

Table 12.2. General profiles of the test persons.

Nr.	Age	Gender	Origin	Profession
TP1	34	M	India	Civil Engineering
TP2	27	F	Indonesia	Traffic Management – Transport Behavior
TP3	38	M	Iran	Ecological Modelling - Marine Engineering
TP4	47	M	Iran	Hydrology & Water Resources
TP5	25	M	China	Geographic Information Science
TP6	24	F	China	Geographic Information Science
TP7	29	M	Pakistan	GIS Software Engineering
TP8	26	F	Pakistan	Geohazards Management

Table 12.3. Experience of the test persons in fields related to the research.

Nr.	GPS systems	Digital maps	PDA	Mobile navigation apps
TP1	Modest	Very good	Very good	Very good
TP2	Poor	Modest	Modest	Modest
TP3	Modest	Modest	Modest	Poor
TP4	Poor	No	No	No
TP5	Modest	Very good	No	No
TP6	Poor	Very good	No	No
TP7	Modest	Modest	Modest	Poor
TP8	Modest	No	No	Poor

Most of the test persons had already visited Amsterdam in the past, but no one had been to the test areas and they were thus unfamiliar with them. Besides, no one had previous experience with any of the two geo-mobile applications used in the experiment.

A questionnaire was applied to find out more about the ways in which the test persons normally use and combine different sources of information when they try to orientate and navigate in space:

Most of the participants always or frequently prepare themselves before they go to an unfamiliar city or area and the others sometimes do that. The main sources of information for them are city maps, either printed on paper or consulted on a computer screen. Finding on the map the public transportation stations and the routes to their places of stay, together with points of interest and prominent buildings, are their most important goals. One of the participants also mentioned the need to see pictures of the points of interest in the city so that they can be recognized easily later. Asking other people that have already visited the place is also important for half of the participants, in order to learn about important points of interest that they should visit or can use as landmarks for orientation and navigation purposes.

All test persons sometimes or frequently take the responsibility of orientation and navigation, and the use of paper maps is a common task for them. However, this does not imply that they always complete these tasks with ease, as all of them have sometimes or even always (TP6, TP8) difficulties to orientate themselves in unfamiliar areas with the use of paper maps.

Only one test person (TP2) makes frequent use of mobile navigators when travelling to an unfamiliar place, while the others never do that. This is an interesting outcome of the questionnaire, as half of the participants had answered earlier that they have some experience with mobile navigators.

After their arrival in an unfamiliar city, more than half of the test persons inspects the layout of the city, and the patterns of the streets, in order to try to understand the city better and not to get lost. Besides, half of them are trying to find and locate some easily distinguishable landmarks: churches or other tall buildings (3), train/bus stations (2), big shops, restaurants (1) and rivers (1). When they do get lost, half

of them are trying to find their way through street name information, compared to a map, or to find a previously memorized landmark such as a church, a transportation terminal or a big building. Less than half of the test persons would also ask local people to explain to them where they exactly are and to point their position on a map that they may carry. One of the participants (TP1) also uses the sun direction and tries to re-orient the map towards the North.

All test persons find their orientation and navigation abilities improved when they are visiting the city for a second time. According to them, the reason is the memorization of transport stations (2), tall structures, buildings and city centers (3), patterns of the cities (1), previous routes (1), appearance of roads (1) and any other easily distinguishable / unique features (1).

12.3.5 Study Area

Amsterdam was the selected city for the experiment for three reasons. First, it is visited by many people (e.g. tourists) who have not been there before and they often go there by public transport. Secondly, Amsterdam (Department of "Stadstoezicht") takes part in the UWSM2 project as well, as the municipality would like to use a geo-mobile application in relation with parking services. And, thirdly, the train trip from Enschede (the temporary dwelling-place of almost all test persons) allows for interaction between the researcher and the test persons in order to prepare the latter for the experiment and acquire some important additional research data.

For executing the tests, two different areas of Amsterdam with different environmental parameters were selected, in order to investigate how this diversity influences the personal geo-identification and navigation of the test persons. The first (based on the test route) was Wibautstraat Metro station (start) – Krugerplein (1st destination) – Amstel Metro Station (2nd destination) and the second was Dam Square (start) – Begijnhof (1st destination) – Rembrandt House (2nd destination) These can be seen in *Figure 12.3*. The first area has less diversity of features (neighbourhoods mostly comprised of houses) and the second includes many prominent places that could be used as landmarks (churches, governmental buildings, historical places).

12.3.6 Research Methods and Techniques

The testing methodology involved a questionnaire at the start, thinking aloud with audio/visual observation and synchronous screen logging and a semi-structured interview at the end. This combination of methods allows for a deep investigation of the test persons' thoughts and actions, and keeps, at the same time, records of all the test activities. The resulting research materials may be thoroughly and objectively analyzed afterwards (Delikostidis 2007, Van Elzaker et al. 2008).



Fig. 12.3. The test areas Wibautstraat-Krugerplein-Amstelstation and Dam Square-Begijnhof-Rembrandt House placed in Google Earth.

The questionnaire had the aim of creating a general profile of the test persons, involving their experience, knowledge and way of acting in fields related to this experiment. Thinking aloud proved to be a very valuable technique for acquiring information about the test persons' thoughts and the reasoning behind their acts, especially in parts where they were confused. During the interview at the end the test persons could also discuss additional issues and could also be asked several questions depending on their previous answers. This was especially useful for clearing things out when there was a noticeable difference between answers of particular test persons in the initial questionnaire and their behaviour and acts during the survey.

The test persons were also asked to draw two mental maps, depicting their place of residence and the route that they followed during the testing. The first mental map was drawn after completing the questionnaire and the second one after finishing the interview. In these drawings they were supposed to include the geographical objects they found important. From the mental map drawings a lot of information can be retrieved, such as the type of landmarks memorized, the points of confusion and the possible reasons for that and the individual's orientation abilities.

The 8 test persons were divided in two groups of 4 people each, one group for each of the two study areas in Amsterdam. The test persons in both groups were asked to use the two selected geo-mobile applications one after the other, performing one navigation task with each application. Each test started by asking the test person to try to orientate with the help of the first geo-mobile application without using street names and then select and follow the shortest route to navigate towards the first destination. After reaching that point, the second application was used in order to

execute the same tasks targeting to the second destination. The order of applications was changed every time for comparison reasons.

Although the real contexts of use are dynamic and even unpredictable up to some extent, a set of conditions was applied to the test sessions in order to limit the context diversity as much as possible. The test sessions were only executed during daytime (from 8:00 to 20:00 hrs in the months May and June 2008), in fair weather conditions (cloudy or sunny days, with average temperature and wind speed) and not in highly disturbing instances (demonstrations, national celebrations, road work and the like) in the survey areas.

Before the actual involvement of the test persons, a pilot study took place in the selected areas in order to calculate the required average times for the completion of each task, to test the equipment in real conditions and find out possible problems or limitations that could affect the execution of the tests. After the pilot study, some adjustments to the survey settings had to be made. The initially estimated timings of the different parts of the test were revised and some of the equipment was calibrated in order to work properly with respect to the field's specific parameters (high environmental and electromagnetic noise, possibility of short-time light rain, low GPS signal in narrow streets).

12.3.7 Briefing and Training of the Test Persons

During the transportation of the test persons from Enschede to the test areas by train (two test persons per day) the test persons were first asked to complete the questionnaire and then draw the mental map of their place of residence. Then they were given the mobile device (a PDA HP iPAQ 4700hx and later a PDA-smartphone i-mate Ultimate 9502) running iGo My way 8.0 and Google Maps, with the latter running offline using Google Navigator software (URL 8). The GPS receiver of the mobile device was on while the train was moving, so that the test persons could better understand how each mobile application was working, how they could use the basic functions (zooming, panning) and how the viewing perspective could be changed from 2D to 3D and vice versa. Two city and street name finding tasks involving zooming and panning were also given to the test persons, in order to make them more familiar with the functionalities and interface of the geo-mobile applications. The test persons were informed that the test would start as soon as they had reached the Wibautstraat Metro station (for test persons in the first group), and Dam Square for those in the second group. Additional instructions regarding the execution of the tests and information regarding personal and equipment safety were given as well.

12.4 Mobile Observation and Thinking Aloud in the Field

In order to carry out the experiment, a special technical solution for field-based observation/recording was used. It is based on a system that was already implemented during a previous investigation on methodologies for field-based usability evaluation of geo-mobile applications (Delikostidis 2007, Van Elzakker et al. 2008). This system consisted of several electronic devices, such as two pairs of audio transceivers, three B&W cameras, a laptop, a handheld video recorder, two pairs of video transceivers and a video quad processor. This complicated system was needed in order to reduce the bias from the researcher physically being too close to the test persons, to minimize the human resources required for carrying out the test sessions and to facilitate the analysis of the recorded research materials through synchronization. With this system, the thinking aloud audio signal, the camera observations of the user, the environment and his/her interaction with the mobile device and the logging of the changes on the screen were synchronically recorded with a date/time stamp. The context of use and the participants' activities and expressed thoughts could thus be analyzed later with accuracy, speed and convenience.

For this experiment, the original system was improved and upgraded in order to offer higher reliability, simplicity and performance. Its main parts are a pair of DECT phones connected to headsets, a hard disk-based four-channel mobile video/audio recorder, three high resolution and wide view colour cameras, two pairs of video

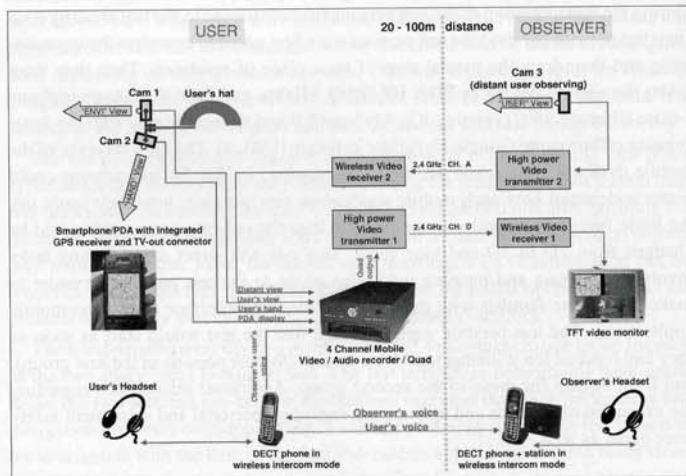


Fig. 12.4. Schematic diagram of the field observation/recording system.

transceivers, a TFT colour video monitor and a mobile device, an i-mate Ultimate 9502 with integrated GPS receiver and video-out capability, running Windows Mobile 6.0 (Figure 12.4). The DECT phones were used as wireless intercoms offering good quality and uninterrupted audio communication between the researcher and the test persons during the sessions. The pair of headsets that both of them were wearing was connected to the DECT phones, through which the thinking aloud could be performed and through which researcher and test person could interact.

The test person wore a hat with two of the colour cameras attached on it. The first one captured his/her interaction with the mobile device and the second one their actual viewpoint. A third camera was carried by the observer, capturing the interaction of the test persons with the environment from a fair distance (20 to 100 meters) and sending this image wirelessly to the user's video receiver. In addition to these inputs, a real-time screen capture of the mobile device display was provided through its integrated composite-type video output.

All the four video signals together with the audio communication were recorded in the 4-channel mobile video/audio recorder, which has enough storage space for many hours of continuous recording. The advantage of using a 4-channel system rather than a single channel one is the higher quality of video per channel, while at the same time there is synchronization between the video/audio channels and date/time stamping which has the benefits described earlier. The researcher could observe all the recorded video signals wirelessly and simultaneously in a quad view (four images in one screen) on the colour monitor that he carried, through a pair of video transmitter/receivers connected to the mobile recorder and the monitor respectively (Figure 12.5).



Fig. 12.5. Sample screenshot of the video recordings of the system.



Fig. 12.6. Equipment checking and final instructions to the test person just before the start of a test session at the Dam Square.

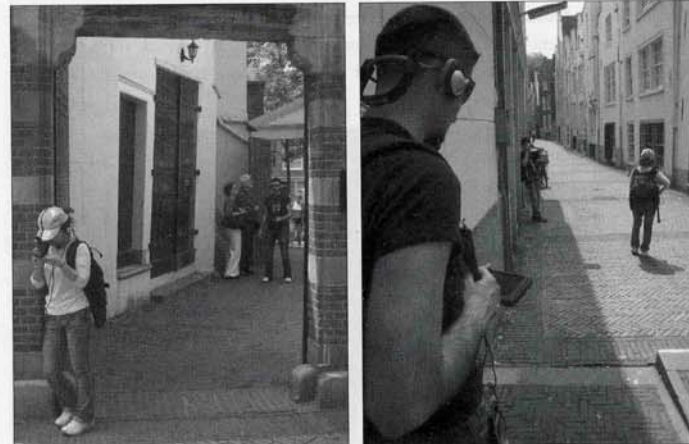


Fig. 12.7. One of the test persons thinking aloud while trying to orientate in front of Begijnhof entrance. The researcher is observing the participant's interactions through the video monitor.

This configuration also overcomes the issue of battery power shortages that came to light in the earlier research. It allows the continuous use of the system for many hours by simply charging a pair of lithium-ion battery clusters for powering the several devices beforehand.

When the researcher/observer and the test persons reached the starting-point, a preparation and installation of the devices of the field observation and recording system was taking place for about 5 to 10 minutes. After that, a few final instructions were given to the test persons and they were able to start the test (Figure 12.6).

During the test sessions, the participants had to think aloud about their thoughts, decisions and confusions. The researcher was frequently reminding them to speak aloud every time they forgot to do so, asking them questions and encouraging them to try finding alternative ways to solve their problems. In order to be able to derive useful conclusions about the interaction between mental maps, reality and mobile maps, the test persons were frequently asked to describe what are the landmarks, features, patterns or any other type of information that they use to orientate and navigate in each situation. It was considered important to inspect what the test persons were looking at during the task execution, even though they were sometimes doing that unconsciously. Questions to the users triggered by these instances provided very interesting and valuable answers. These answers helped in formulating hypotheses about the connections between the real and virtual worlds and in better understanding the process of geo-identification (Figure 12.7).

12.5 Results and Analysis

12.5.1 Task Execution

The test sessions took place between 24 May and 14 June 2008. In general, there were no major problems with respect to the research methodology. There were only a few minor random technical problems with the electronic devices used, which could be expected in this type of research.

The test persons were encouraged to think aloud during the test sessions while trying to orientate and navigate with the use of a geo-mobile application. However, thinking aloud was not always easy for them. In several cases the test persons stopped walking and were trying to say what they think. Outside this apparent verbalization problem, the think aloud method led to valuable results, especially in instances where the test persons were confused about, for example, the selection of a path or direction of movement.

Disturbance by residents or tourists asking us what exactly was the subject of our research was one of the issues we expected to be confronted with. Although that happened a few times during the test sessions, it did not influence their proper

execution. Providing a fast and polite explanation was an effective solution that worked in every instance.

12.5.2 Mental Maps

The mental map drawings of Enschede (the town of residence for most of the participants) and those of the test areas, give an overview of what landmarks the test persons find important to be stored in their minds. They also demonstrate differences from person to person in terms of perception of space and easiness of building mental maps of new areas.

Figure 12.8 shows the mental maps of one test area of two different test persons: TP2 and TP5. The park near destination point 2 and the canal are included in both drawings. The main roads are also very important for both of them, and TP2 even remembers the name of one road. Although during the actual testing both of these test persons found the rail track very important to orientate themselves, it was only included in TP2's mental map. TP5, on the other hand, included a big roundabout existing near destination point 3. This roundabout was a point of confusion for that participant during the testing, as it was difficult for him to select which of the surrounding streets was the correct one to follow.

Landmarks and features that most of the participants included in their mental map drawings were main roads, places of residence and work, transport stations, railroads, tall buildings, squares and parks, big shops/supermarkets, center of cities

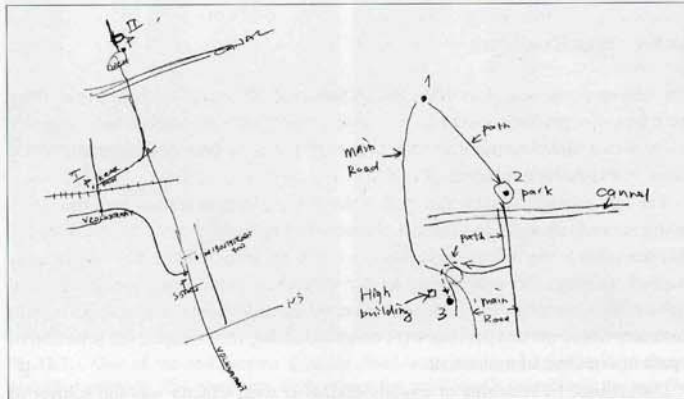


Fig. 12.8. The test area Wibautstraat-Krugerplein-Amstelstation as perceived and represented by TP2 (left) and TP5 (right) respectively.

and canals/streams. However, a major complaint of the test persons was that they could actually not collect as much information of the environment as they would if they would not use the geo-mobile application continuously. For example, two participants mentioned that they would memorize the location and appearance of shops or they would have noticed several tall buildings along their route if they were using a paper map or no map at all. Apparently, they found it difficult to focus on the virtual and real world at the same time.

12.5.3 Test Outcomes

The results of semi-structured interviews, combined with the answers to the questionnaire, the think aloud protocols and video recordings of the observations and screen logging during the actual tests and the mental map drawings were used to answer the research questions. Only a selection of outcomes can be presented here:

The first information that test persons as visitors to an unfamiliar city searched for in order to geo-identify themselves was their position on the map display through the GPS location arrow. They then linked this to the patterns and sizes of the streets on the map, compared to those in reality, as seeking for street names was not allowed at the starting points. It became clear that for personal geo-identification and navigation with the help of geo-mobile applications, the test persons preferred simple map displays with clear colouring and road sizing related to the actual size of the roads in reality. In this respect they preferred Google mobile maps, but they missed important landmarks on the map displays of this application.

The types of landmarks and features that helped the test persons to orientate and navigate during the tests were the canals, the road patterns and sizes, the street names and the parks/squares and roundabouts. Landmarks that would help them but were not (always) available on the map displays are the bridges, pedestrian paths crossing roads, important buildings, such as municipal offices, or tall buildings that are visible from a distance. Specific landmarks that they expect to come across in order to help them to find their way in an unfamiliar city are big shops and easily distinguishable restaurants, such as fast food branches, churches, noticeable monuments, canals, bridges and parks. Besides, it appeared that the types of landmarks in both the users' mental maps and the mobile maps to support their geo-identification and navigation/wayfinding partly depend on the type of the area. For example, canals and bridges were perceived as very useful landmarks in Amsterdam. Or, in an area with not so many prominent features, a small park or a roundabout gains more importance than in an area with many easily distinguishable buildings. On the map displays, the landmarks should be made more distinguishable (colour, shape, size) or additional information should be provided (photos, text). It was found that applying advanced solutions to the issue of landmark visualization is not always better.

Indeed, as it comes to 3D representation and 3D building models on mobile maps, most of the test persons indicated that it is confusing to have a plethora of 3D buildings on the map and they would prefer to only see important 3D landmarks (which would make the software running faster and smoother as well). One of the participants complained about the perspective view of the 3D maps which is not a human-eye view but a bird-eye one, making it difficult to interpret the image of the map correctly inside the human mind. Indeed, most users preferred to use the 2D rather than the 3D map display in this research. However, in this respect no general conclusions can be drawn, as the test persons could not really get used to the different visualizations in the relatively short time of the experiment. The 3D map interface had more functions than the 2D and many persons confessed that they were afraid to use it as they were getting confused with the totally different way of visualization. They confirmed that the 3D models of the buildings could improve their mental connection with the mobile map, but stated that there should be a careful selection of which types of buildings/landmarks should be included in the map. In iGO 8, for example, they found the screen overloaded with too many 3D buildings making it difficult and slow for them to use the map. At the same time, the similar colours that were applied to the different buildings made it often impossible to understand which one is the building that they were looking at in front of them. Most test persons argued that a pop-up photo of a landmark would be more helpful (and less CPU power-consuming) than their 3D representation. In this regard, photos of corner buildings would be critical for the orientation of TP7, as they would allow fast selection of the correct streets. Continuously visible house numbering would also be a helpful for orientation and navigation, together with a very accurate street size/pattern visualization according to reality. Including railroads, building blocks and pedestrian paths was considered to be important by many test persons as well.

In many cases, test persons could not properly connect landmarks of reality to the mobile map displays as they were either not visible at all on the latter, or they were appearing and disappearing in different zoom levels. Sometimes they were not represented in an easily perceivable form. As it comes to the "mental" landmarks of the users, things were a little bit more complicated. Next to the representation issues already mentioned, the development of their mental maps based on landmarks was decelerated by their looking at the mobile screen most of the time. The majority of test persons argued that if they had used a paper map (or no map at all) they would have developed, combined and memorized more landmarks.

Despite all this, test persons did use landmarks as points of connection between reality and its graphic representation in the form of mobile maps and they tried to orientate the mobile map towards the position and direction of the real landmarks. This was problematic in areas where there was low diversity of structural elements in the environment. The test persons got confused/disorientated many times when they

were trying to rely merely on the position arrow on the map, as this is not a very accurate navigation tool during walking speeds. It appeared that most test persons found the position arrow on the mobile maps very important, and complained about its inaccuracy in showing the actual direction of movement. They made mistakes during navigation because they tried to follow the arrow, despite the fact that they were continuously informed by the researcher not to rely exclusively on that and try to find other sources of information to understand where they are. The problem is that GPS signal-based position arrows on mobile maps cannot work reliably when the speed of movement is low, as what is happening during pedestrian navigation. Obviously, the test persons would prefer a map continuously rotating towards the direction of their movement and towards their point of view when they are not moving.

A last issue related to personal geo-identification and navigation is the sequential need for overview and detailed map displays. Although iGO 8 has smooth zooming capabilities, none of the participants noticed that during the tests. The possible reason for this finding is that in densely built up areas, such as Amsterdam, the software cannot process the geographic data fast enough in a common mobile device in order to achieve graphically smooth changes during zooming in and out. This technical problem is also addressed in the UWSM2 project.

During the tests, most of the test persons found it easier to keep an overview map of the area in their minds while inspecting a more detailed view. However, they agreed that frequent zooming in and out is required in order not to lose the contact between reality and the maps in their minds. In case of a total loss of the GPS signal, as a consequence of which they would have to find their way through a static mobile map, most test persons would use the road names and the street sizes and patterns in order to first understand where they are and then navigate.

12.6 Conclusions

This paper presented the findings of a field-based experiment investigating the interactions of visitors to unfamiliar cities with the environment, their mental maps and the (carto)graphic interface of two geo-mobile applications. The experiment applied a combination of qualitative research methods and techniques supported by a special technical solution for field-based user research. The results of this experiment contribute to the requirements analysis stage of the user-centred design of a prototype of a more usable geo-mobile application and to finding solutions for automatic mobile map generalization, brought about by the need for zooming, as strived for in the UWSM2 project.

Some of the results that could directly contribute into making guidelines for more usable geo-mobile applications are the determination of the types of landmarks that

support user geo-identification and should be included in mobile map interfaces, the representation of these landmarks as a combination of unique icons and popping-up windows showing pictorial and text information. The zoom levels that are mostly used and the landmarks and information that is missing in specific types of points of confusion in current geo-applications can additionally be determined by a more thorough analysis of the existing thinking aloud data.

Further research is needed, though, not only to compare smooth and step-wise zooming, but also in terms of proper visualization of environmental and mental landmarks on mobile (carto)graphic interfaces for pedestrian navigation. Determining the map scales at which particular types of landmarks should remain visible or at which their visual characteristics should be changed depending on the user's requirements and preferences and the context of use is one of the issues to be addressed. Minimizing the need to use the zooming function by properly selecting and generalizing important structural components including landmarks and by applying user-friendly zooming techniques is another one. In this regard, a future field-based research focusing more into the usability of smooth zooming in real contexts, as compared to step-wise zooming, is required. This could be done once the technical problems of geodata transfer have been solved, perhaps by the other results of the UWSM2 project.

In any case, finding proper ways to connect the real and virtual geographic worlds that the user of geo-mobile applications interfaces with, could be one of the keys to developing more usable geo-mobile applications.

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URLs

- URL 1: RGI-233 research project on Usable (and Well-scaled) Mobile Maps, <http://www.rgi-otb.nl/uwsm2/>
- URL 2: Agis Navigator, <http://www.asiagis.com.sg/agis/index.htm>
- URL 3: Alturion GPS Professional v.6.0, www.alturion.com/products/detailsphp?id=59
- URL 4: amAze v. 4.2, <http://www.amazegps.com/welcome.php?language=en>
- URL 5: CoPilot live v.7.0, <http://www.alk.com/copilot/>
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