Need for Context-Aware Topographic Maps in Mobile Devices

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Abstract. Recently, along with the breakthrough of the Internet and mobile environment, the development towards screen maps used as intelligent user interfaces appears to be emergent. This means that if we consider the map on a mobile device to be one type of a graphical user interface, the same usability issues that occur in other software development must also be involved. In the present paper we propose that embedding context awareness into the maps could increase the usability of mobile map services. The mobile contexts, from the map users' points of view, are examined here, based on user tests of topographic maps in PDA. Today, the most important context of use for mobile map services is location of the user. However, the users' needs with respect to also adapting maps in mobile devices to other context elements, in addition to location, appear obvious. Several other context elements worthy of attention identified in the field test include purpose of use, time, physical surroundings, navigation history, user and cultural and social elements. In this paper a new categorization for mobile contexts in map services, based on test results, is given and discussed.

1 Introduction

When designing new products for users in general, it is essential to know beforehand what the real needs of the users are, to make the products usable and saleable. This also applies to map products. Users need various types of maps in different situations and when usability of maps is concerned, one of the main issues is that the user has the right type of map, at a suitable scale and with the symbology adapted for the specific usage situation. Originally, the responsibility for having on hand an appropriate map in each usage situation is part of the users' tasks. In turn, the responsibility of the map producer includes that the map is accurate, the information presented is up-to-date and the visualization of the map is of high quality.

As graphical user interfaces (GUIs) in software engineering, maps could also be regarded as user interfaces (UIs); e.g. Kraak and Ormeling [9] described maps as interfaces to geographical information systems (GISs). Kraak and Brown [10] stated that due to the multimedia nature of the Web, maps can be seen as interfaces or also as indices to additional information. Peterson [20] also suggested that the word interface can be related to maps in two ways: maps are firstly interfaces to the world and secondly are composed of UI elements. The layout of the map, the legend, its colours, sectioning and folding, are all aspects of the map's UI and there is interaction between map and user when the map is used.

Intelligence in user interfaces could be described e.g. as a way to make the system more adaptive and flexible for each situation and user. Lieberman and Selker [13] stated that a considerable portion of artificial intelligence or good design in human-computer interaction (HCI) amounts to being sensitive to the context. In other words, intelligence could be implemented into UIs by making them aware of the context. Furthermore, when mobile map services are concerned, there are new possibilities of embedding additional intelligence into the map. In this paper we study context awareness from the map point of view, focusing on topographic maps in mobile devices. Our studies are based on results acquired from field tests. We propose that embedding context awareness into topographic maps in mobile devices could increase the intelligence and the usability of mobile map services. Finally, in the paper a new categorization for mobile contexts in map services is given and discussed.

1.1 User Tests as a Background

The mobile contexts examined below in Section 4 are based on field test results from user tests with topographic maps in a Personal Digital Assistant (PDA) in Nuuksio National Park, Finland. The user tests were part of the Geospatial Info-Mobility Service by Real-Time Data-Integration and Generalisation (GiMoDig) project [6]. The purpose of the GiMoDig research and development project is to improve accessibility and interoperability of national topographic databases [25]. A prototype system providing geospatial service will be implemented and used as a test bed in the project. User testing was carried out in cooperation with the KEN project (Key Usability and Ethical Issues), which was one of the horizontal support projects in the Finnish Personal Navigation (NAVI) research and development programme. User test results will be further used to develop principles for context-aware topographic maps and a suitable UI for the GiMoDig service.

The maps in the PDAs used in the tests were derived from the Topographic Database (TD) of the National Land Survey of Finland (at a scale of 1:10 000). The data from the TD were generalized and the symbology modified to better suit the small display of a mobile device. In Nuuksio National Park the users were asked to complete predefined test tasks using these topographic maps. They were e.g. asked to look for a suitable campsite from the map, describe the mental image of the site they chose with the information based on the map view, and finally navigate to the selected campsite using maps in the PDA.

The PDA used during the field tests was Compaq's Pocket PC with Genimap's Navigator LT software. Two observers monitored the users during the test and interviewed them in the usage situations. Tests were also documented with minidisks and video cameras. During the tests users were asked to identify what their needs were for context awareness on maps in mobile devices. The examples given by the users are analysed and categorized in the present study.

The following Section 2 discusses about the maps in general and the new demands they are facing when bringing them into mobile environments. In Section 3 the former studies on context and context awareness are examined. A proposal for a new context categorization based on the field tests is presented in Section 4. Finally, discussion and conclusions are given in Sections 5 and 6.

2 Tasks and the Usability of Maps in Mobile Devices

MacEachren [14] argued that there is no single correct scientific, or nonscientific, approach as to how maps should work. He examined the map not as a communication vehicle, but as one of many potential representations of phenomena in space that a user may draw upon as a source of information or an aid to decision-making and behaviour in space. While the most important task of maps is to visualize the features and their relative locations in reality, the mobile environment allows for other useful tasks. Reichenbacher [22] listed four main groups of user tasks:

1) locators: compare the features on the map*: Where am I? Where is the destination?*
2) proximity: *Where is the nearest bus stop?*
3) navigation: *Show me the way from A to B?*
4) events: *Is it raining in a particular place?*

In addition to these, the measurement task on a map is of course one of the original purposes. In a new mobile environment an example might be: *How far is the destination from my current position?*

Typically, the fastest way to produce maps during the first stage of providing maps to mobile devices was to use the same visualization as in desktop and Internet applications. However, the main problem turned out to be the presence of totally different usage situations. Maps in mobile devices are often used in outdoor situations, which means that their visualization should be totally different compared with indoor situations in office desktops. And not only the visualization, but also the information needed and used in the mobile environment, should be distinctly different [24].

Kraak and Brown [10] divide web maps into static and dynamic maps. Static maps can often be seen as the traditional cartographic products, which are put on the Web as bit maps by scanning them, while dynamic maps can be either in animation format or in vector graphic formats. Both types of maps can be either view-only or interactive maps. Web maps can be made for special situations for special users and can be updated and changed only from the source code. Users are then able to see the new versions immediately.

Some examples of the level of functionality of maps familiar from the Web are that the user can interactively ask the map to show only the information the user is interested in or the user can ask that additional information be shown on top of a topographic map. Changing from one scale to another is also possible in the same view and the user does not have to change the equipment (with paper maps, the user has to change from one map to another). The information included can vary in different maps, as can the symbology of how the information is presented in the map view. These matters and the fact that maps may be transmitted over networks place some constraints on the design and physical nature of web maps from the perspective of both the producer and the user. This means that if we consider map in mobile device to be also one type of a GUI, the design principles for maps should also include the design principles used in other GUI designs. When map usability is the issue, the same basic principles as in other software development [17] must be considered. Furthermore, the same design principles used for making good UIs can also be adapted when designing maps to be displayed in mobile devices.

3 Definitions of Context

Generally speaking, intelligence could be implemented into UIs e.g. by making them aware of the context. By doing this, system could become more adaptive and flexible for each situation and user. In this study it is thought that this applies to the maps in mobile devices, too. Before categorization of context awareness needs in mobile map environments (in Section 4), the previous studies of context definitions are examined in the following.

3.1 General Definitions of Context

Chen and Kotz [4] defined context as "the set of environmental states and settings that either determines an application's behavior or in which an application event occurs and is interesting to the user". Dey's [5] definition for context is not far from the previous: "context is any information that can be used to characterize the situation of an entity, where entity means a person, place, or object, which is relevant to the interaction between a user and an application, including the user and the applications themselves". Dey also defined the system to be *context-aware* if it uses context to provide relevant information and/or services to the user, in which the relevancy depends on the user's task.

3.2 Previous Classifications of Context Awareness

More specific context definitions were suggested, e.g. by Schilit et al. [26] who stated that context could be divided into three categories. The first is *computing context* (such as network connectivity, communication bandwidth and nearby resources such as printers and displays). The second category is *user context* (such as the user's profile, location, people nearby and the current social situation) and the last category is *physical context* (lighting, noise levels, traffic conditions and temperature). Chen et al. [4] proposed a fourth category, which is *time context* (such as time of day, week, month and season of the year). They also mentioned *context history*, which could also be information useful in map applications.

The different context categories can also be grouped according to their complexity of functionality. Chen and Kotz [4] stated that low-level contexts consist of time, location, network bandwidth and orientation whereas high-level contexts consist of e.g. user's current activity and complex social context.

In the following section the paper focuses on defining the contexts relevant for mobile map usage, which were identified during the Nuuksio user tests.

4 Categorization of Context in Mobile Map Services

To consider the usability issues, pilot user tests were arranged early in the GiMoDig project. At that time there had not yet been real prototypes available for testing, so the purpose was to obtain some basic information on the usability of topographic maps in mobile devices and also to gain experience on how to plan and carry out user tests during the later stages of the project. Based on the field tests, reclassification of the contexts was performed compared with earlier research, as discussed above. In the following sections some mobile contexts, which can be used to create future intelligent maps for mobile devices, are described. Context descriptions also include examples of possible usage situations, in which the context awareness may give some additional intelligence from the users' points of view. The examples are actual demands and ideas figured out by users during the field tests.

The following descriptions do not focus on, and are not limited by, technical matters. Therefore we do not attempt to claim that all of the ideas that came up during the user tests could be realistically implemented with today's technology. However, some of the elements for context awareness listed here may be worthwhile to include in the map application to make it usable. The needs for context awareness presented are specialized for use with topographic maps in field situations in forested areas. The needs may be totally different in different map usage situations (e.g. city navigation, road navigation). The contexts listed below are summarized at the end of this section.

4.1 Context – Location

During the field tests, the users clearly indicated that the most important advantage of digital mobile maps compared with traditional paper maps is the information of the user's current location. Users believed that without it there could be no critical difference between the benefits gained with traditional maps or screen maps. This result as such was not great surprise, since several researchers had already pointed out the importance of location for future development [11], [12].

Currently, positioning systems are quite easily embedded in mobile systems. There are commercial products that use the Global Positioning System (GPS); mobile phones with integrated GPS modules, GPS devices that can be integrated into mobile phones and separate GPS modules for PDAs. Mobile phones can also be located by the telecom operator in the network using various methods for calculating the distances to overlapping cells. The third way of locating the user is by identifying him at a service point (in a certain area), e.g. using a Wireless Local Area Network

(WLAN), Bluetooth or infrared technologies. For this the user needs special devices, which are actually becoming common in mobile devices today.

One example of how to bring context awareness to mobile applications was defined by Brown [3], who presented the stick-e document in which the users can place a message on their PDA in their current position, and whenever the user returns to the same place, the message is triggered and brought to the user's attention. In our field tests, a similar need for context awareness emerged when the users felt that they would like to save e.g. the location of a good blueberry patch or fishing site. The urban area example of how to use the location information was presented by Marmasse and Schamandt [15], who used the location in the *comMotion* computing environment, which links personal information to locations in its user's life e.g. by showing the user's current position and nearby locales, such as banks, movie theatres etc. when requested.

Information on the user's location can be used by itself or in combination with other context information; e.g. the navigational history context, dealt with later on in this section, is based on interpreting location information history. The basic use of location, however, is to show the user's position on the map in real-time. This is done currently by moving the cursor, which shows the location of the user, at the top of the map or by keeping the cursor in the centre of the display at all times and moving the map underneath according to the user's movement.

Information on the user's location could also be used when the user is navigating along the planned route. The system could offer a new route if the user wanders further from the originally planned course, which may be the situation when the user decides to go off-route, e.g. when seeing a beautiful view nearby. The maps could take advantage of information on the user's location by providing different types of information according to the user's surrounding area (whether rural or urban) for aiding in navigation.

A use scenario example of how to use location information at a more sophisticated context-aware level (not only a cursor at the top of the map) could be the following hypothetical situation in Nuuksio National Park:

> *It has not been raining for a long time in southern Finland and there is a potential forest fire hazard in the area. As a result, users are allowed to make campfires only in very strictly defined areas in the national parks. This meteorological information could be delivered to all the mobile devices arriving in national park areas by using information on the location of the devices. The maps provided to the user could also be adapted to the current situation so that they could enhance only permitted campfire sites. Maps could also offer some additional information on the issue by providing links at the top of the map.*

4.2 Context – System

The variety of mobile devices is growing and users expect to be able to use the same types of service on the various devices, according to Kaasinen [8]. It requires much work and abundant time and space in the databases to plan and store different maps suitable for various situations. One possible solution could be to use the same databases continuously, but the application would need to understand the hardware and software limits and also be aware of where the map will be used. By this we mean that the system providing the map should recognize the end-device from which the map request originates and should return the information in the right format so that the map would be suitable for the current device (e.g. with its display and functions).

Martikainen [16] stated that this also concerns the situation more generally, since the growing variety of Internet devices makes enterprises more reliant on user interface languages that are device-independent. By using these types of languages, the content could be delivered and transformed automatically from the single-user interface description into appropriate formats for the different types of devices.

The system properties that were considered to be the main issues, when the map is adapted to the different mobile devices included differing sizes of the screens, function buttons and screen colours (colour or black-and-white screen). Other context awareness related to the system could include information on the processing power and memory capabilities of the device, so that the system could also take them into account when delivering the information for the mobile map.

One of the system properties is also the input method, meaning that some of the mobile devices are used with pens or touch panels. It may be relevant in some situations, that the map presented could also be created by knowing the input context, i.e. how the map could be processed. Rekimoto [23] suggested tilting of the device itself to be the input method. We think that this could be useful for map usage in field situations. The map may be processed by moving the mobile device in relation to the user (zooming by moving the device closer and further from the user's face and scrolling the view by horizontally tilting the device). It was also suggested during the tests that the usability of a mobile map in field situations could be improved if the map were to give an audible navigational aid and also act on audible commands.

4.3 Context – Purpose of Use

One of the most challenging contexts to be considered is the user's purpose for using the map, in other words, what he intends to do with it (see Figure 1). In using the application itself, it is probably very difficult to identify where the user may need the map and for what purpose. Most likely this context should be defined by the user. The problem here is that active personalization may not be very tempting from the user's point of view, although it may be very useful in many cases by providing the right maps for the usage situations. But in most cases the situation in mobile devices is that the surrounding context changes but the user remains the same for the device. So once given very specific and detailed personalization followed by only small amounts of information on the current situation, it may be even worthwhile in some situations.

In the Nuuksio field tests, the users came up with many different use situations in which they might have needed specific maps. The maps that professional orienteers may desire of the area would probably need abundant detailed topographic information (on rocks, waterways etc.), whereas a family with four children may only need information on the main tracks, campsites and beaches in the area. Some users also thought that maps showing the good areas for picking cloudberries or mushrooms may be useful in some situations, as well as maps with good fishing locations in other situations. It would be useless to show all of this information on everybody's map; thus the maps could be adapted to each particular situation and purpose of use. In some situations it was considered to be useful and interesting if the map could have information on the history of the user's personalization, e.g. 'in this area the user was last interested in where good blueberry patches were; let's have that as a default this time'. But before making any assumptions on the user's current tasks, the system should probably ask the user to confirm the system's interpretation of the context.

Fig. 1. Knowing the purpose of the user is essential to the usability of map applications.

4.4 Context – Time

There are at least two main categories included in the time context: time of day and time of year. Context awareness of the time of day could affect the map, e.g. in situations where the map would only show the cafeterias open at that time or where other information is enhanced, e.g. if the information service is open.

The time of year may also constitute important information from the user's point of view. Maps from areas such as Nuuksio National Park could be totally different during summer and winter seasons. The tracks could be different, because during the winter users are able to ski on the lakes and swamps, whereas information on swimming locations may not be as useful for many people during the winter months. Other points of interest (POIs) along the route may also differ greatly. In addition to information on the time, this part of context awareness knowledge could also incorporate information, e.g. from meteorological databases, such as thickness of the snow or ice in the area or the temperature of bodies of water used for swimming during summer.

4.5 Context – Physical Surroundings

The user's physical surroundings can vary widely during the use of maps in mobile devices. Kaasinen [8] divided physical context into illumination, background noise, temperature and weather. During our tests users expressed no need for information on background noise or temperature. However, it is very likely that background noise information plays an important future role when using voice interfaces in mobile devices. Illumination and the brightness of light were found to be somewhat critical in certain situations. When using the mobile map during the day or at night, the map colours and background illumination should be adapted to the surrounding brightness; e.g. Schmidt et al. [27] demonstrated integration of the light sensor in a PDA. Information on the weather was also found to be useful, with integration of user location and local weather forecasts possibly being one way of presenting the map.

Some users desired to have maps suggesting several possible routes to the destination and also giving some additional information on the routes offered (e.g. suitability for different persons, how demanding it is, how long the track is, how long it would require a person to walk to some destination at the current speed, which POIs are along the route, how the terrain varies along the route etc.). Intelligent route suggestions in the field could also take account of the surrounding landscape (lakes, hills etc.).

4.6 Context – Navigation History

The most important requirement for navigating is to know your own location on the planned route. Optional routes to the destination and more detailed information on the services and POIs available along the routes, as well as at the destination, may also be of interest to the user. The map application, which takes account of the users' previous navigational targets and other previous requirements for the route, may be useful in certain situations. This map could offer routes that have the most likely POIs and suitable routes for this user (e.g. if the user has been using cyclist route suggestions, the application could remember and use this information). Context-aware route suggestions could also use other context information, such as previous locations of the user to provide spatial diaries on the user's tracks during the day. Information on the user's navigational history, i.e. the location history, could be used for interpreting the navigational context; e.g. if the user is stationary, he may be having a break and the map could offer more information on the surrounding area.

4.7 Context – Orientation

When observing users during field tests, we noted, that most were rotating the map while walking, so that the actual view in front of them corresponded to the map view on the mobile device. One of the most useful context awareness themes may be information on the user's orientation, which could be measured either with a digital compass or by noting the direction in which the user travels from the user's location history. The map could then be displayed in the right position with respect to the user's line/direction of movement. The benefits of adding some orientation sensors to a PDA have been studied; e.g. by Schmidt et al. [27].

There are some examples of indoor systems, in which the map could be oriented, e.g. based on e.g. the Cricket location system [21], which consists of independent, unconnected beacons distributed throughout a building. Small devices carried by users, infer their locations by using time-of-flight methods. It may also be possible to bring this type of system to small outdoor areas, such as national parks.

4.8 Context – Cultural and Social

Sometimes the usage situations of mobile maps can also differ, due to current cultural and social situations of the user. The social situation appears to be very difficult to measure or sense, but some needs concerning social context awareness were revealed. When people were searching for a peaceful campsite, they often commented that the map could also show all the other mobile devices in the area, enabling the user to choose the site with the fewest campers. In a different situation the map could show only those cottages with sleeping accommodations left. One social context awareness application may also be in a car's navigation system, in which routes for drivers could be suggested, using traffic information on traffic jams etc.

Ahonen et al. [1] grouped together some specific features that may vary between cultural areas when using navigational products and services. One of these is the recognizability and local conventions of navigational symbols, as well as the colours used. These can vary and have different meanings in various cultural areas. The names of places and streets and address formats can also be presented in many different languages, e.g. in Finland where in some areas all streets have Finnish as well as Swedish names. Shneiderman [28] listed other cultural issues: characters, left-to-right versus right-to-left versus vertical input, date and time formats, numeric and currency formats, weights and measures, telephone numbers, names and titles, social security, capitalization and punctuation, sorting sequences, icons, buttons, colours, grammar, spelling, policies, formality etc. An intelligent map should be able to recognize the context and give this information to the user in the right format.

4.9 Context – User

In addition to the purpose of use, one of the most difficult characteristics to be interpreted is the user context. Shneiderman [28] discussed the differences occurring among users: physical abilities (height, age, left-right handedness, speed of finger presses etc.), cognitive and perceptual abilities (memory, learning, problem-solving, decision-making etc.) and personality differences (attitudes on computers, habits, personality types such as extroversion vs. introversion, emotional states etc.).

Although many of the variants listed above with Shneiderman are not useful or cannot be used to advantage in mobile map applications, there is still some information on the user, which the application could use automatically. One of these may be interpretation of how the user knows the map symbols and how familiar he is with using the mobile device and the map on it.

4.10 Summary of Context Categorization

Table 1 summarises the context categorization described in this chapter. Categorization is divided into the general contexts (compiled from [4] and [5]) and those contexts that we consider the most important for the mobile map applications, according to our tests. A set of features belonging to each group is listed in the third column.

Table 1. Categorization of contexts and their features for mobile map services

General context categories, [4] [5]	Context categories for mobile maps	Features
▪ Computing	▪ System	▪ Size of a display ▪ Type of the display (black – colour screen) ▪ Input method (touch panels, buttons etc.) ▪ Network connectivity ▪ Communication costs and bandwidth ▪ Nearby resources (printers, displays)
▪ User	▪ Purpose of use ▪ User ▪ Social ▪ Cultural	▪ User's profile (experience, disabilities etc.) ▪ People nearby ▪ Social situation
▪ Physical	▪ Location ▪ Physical surroundings ▪ Orientation	▪ Lighting ▪ Temperature ▪ Surrounding landscape ▪ Weather conditions ▪ Noise levels
▪ Time	▪ Time	▪ Time of day ▪ Week ▪ Month ▪ Season of the year
▪ History	▪ Navigation history	▪ Previous locations ▪ Former requirements and points of interest

Based on our experience from the user tests, we propose that there is a clear need for context awareness in topographic maps in mobile devices. However, much remains for application development before the benefits of context-aware maps can be utilized.

5 Discussion

During the product design process, usability issues are today one of the main approaches affecting the process, mainly because usable applications are those that may sell, if anything will. The developed UIs (including maps in this study) should be studied from the usability point of view throughout the application development project to make possible improvements at an early stage of the process.

The research presented here focuses on the fact that maps can be brought to the mobile environment, with portable computers and wireless communications. This leads to the situation where people want increasingly 'intelligent' systems that would be easy to use. We think that one way of producing maps with more intelligence from the user's viewpoint could be building context awareness on them. Adding context awareness into map services would expand the traditional feasibilities for information presentation offered by traditional paper maps. Within the mobile map usage, context awareness could also aid in map reading and navigation.

But first we need further research on which types of context needs the users have, which of these should be implemented into intelligent map interfaces and what could be the benefits of doing so. The context awareness needs from the map users' points of view were listed in the previous chapter. Defining the word context itself is a challenging task that can be approached from different levels and perspectives, as well as from various research fields. When e.g. mentioning the cultural context, we can either refer to the cultural surroundings of the user during the usage situation or to the user's cultural background. The location can also be grouped under physical context, because it is one of the user's surrounding variants, but it can be grouped under user context as well, because it is something characteristic for the user in every situation. It can be concluded, that the mobile context classification described above is only trend setting, not a strict categorization.

When developing new context-aware applications, the main principles for usability must also work. Therefore it should be carefully ensured when bringing context awareness to map applications, that all the attributes on usability are still considered. Usability is defined by ISO 9241 standard (Ergonomics requirements for office work with visual display terminals) as "the effectiveness, efficiency, and satisfaction with which specified users achieve specified goals in particular environments". Other heuristics and principles, e.g. consistency, feedback, simplicity etc., have been suggested by several researchers, e.g. Nielsen [17], Norman [19] and Shneiderman [28]. Höök [7] suggested that system should also leave the user with the feeling of control, transparency, predictability, privacy and trust in the user's hands. Benyon [2] stated that appropriate methods for studying the usability include heuristic evaluation, formal laboratory-based usability testing, the application of HUI guidelines and structured 'cognitive walkthroughs'. The findings during the Nuuksio tests demonstrated that field-testing seems to be an appropriate method for testing the maps in mobile devices [18].

However, there are several limitations to the results presented here. Firstly, it was beyond the scope of this study to examine the technical feasibility of how to bring the context awareness to the mobile services. It is obvious that not all context awareness needs listed in this paper can actually be implemented in practice at the present day, but they might be possibly implemented in the future. Some needs may also be more useful than others, and although the technical matters were not considered here, it is clear that some of the contexts are much more easily sensed than others. And even if information on some of the context variants may already be available for map applications in mobile environments (e.g. location), utilizing them is still far from being very effective and remains a challenging problem for mobile map application developers to solve.

Secondly, although it seems unlikely, it is possible, that because of the nature of the results (subjective comments by different users) all the contexts relevant are not listed here. And thirdly, it is not enough to know the context of the map use but also to adapt the maps according to the context sensed. All these topics need further research in order to provide appropriate maps for different contexts of mobile map services.

One problem in the future is that the system may sometimes result in wrong interpretations of the contexts and acts on these, which can be very frustrating from the user's point of view. And besides sensing the context, also modelling the map objects in database schema, in order to fulfill the different needs according to the context, has to be solved. Further research is needed also on these topics in order to develop intelligent mobile map services.

6 Conclusions

In this paper we investigated the usability of maps in mobile devices so that improvements could be recommended, based on the user needs for context-aware topographic maps. The test method used here was field-based usability testing, in which the usability problems were identified and the results interpreted in order to give proposals on how to tackle the existing problems. We analysed the results and the user comments and classified them into different context categories. Today, the most important context of use for mobile map services is location of the user. However, several other context elements worthy of attention were identified in this study, including system, purpose of use, time, physical surroundings, navigational history, orientation, user and cultural and social elements. We also proposed that embedding context awareness into the topographic maps in mobile devices could increase the usability of the map services. The results presented in this paper were the actual needs identified and described by the users and it is obvious that the designers should be at least aware of these issues when designing future mobile map services. The technical implementation of the context category remains for our future research. The more the map application knows of its usage context, the more intelligent support it is able to provide to the user.

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