Preventing Interruptions in Mobile Map Reading Process by Personalisation

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ABSTRACT
Cartographers' main objective in map design is to create in the mind of a map reader (i.e. user) an abstraction of the real world appropriate to the map's purpose. The final result depends, not only on the cartographers', but also users' skills and ways to perceive, as well as on the map usage situation. Interruptions during map reading process of mobile maps occur, when the conceptual models of the cartographer and the user do not match, e.g. if the user does not understand the symbols, or the overall layout of the mobile map. This can be frustrating from the users' point of view. It is thought here, that by bringing context awareness into the maps on mobile devices, interruptions in map reading process could be decreased, by providing each user with symbols that are adapted to the usage situation and user preferences in real-time. In this paper some ideas, of how to implement context awareness into mobile maps by personalisation, are presented.

Categories and Subject Descriptors
Implications for adaptive behaviour, Leisure/entertainment use, Personalisation of services

General Terms
Theory, Human aspects

Keywords
Interruption, Mobile map, Personalisation, Cartography, Symbols, Visualisation

1. INTRODUCTION
In this paper two different disciplines of science are combined: sciences of cartography and the human computer interaction (HCI). Due to the cross cutting nature of the paper, the definition of the cartography is first introduced: "A map is a symbolized image of geographical reality, representing selected features or characteristics, resulting from the creative effort of its author's execution of choices, and is designed for use when spatial relationships are of primary relevance" [6]. It can be said, that each map, no matter of the content, is a presentation of the time when it was made: the existing art trends, the existing scientific thoughts and also the available technology [12].

During the former times, the maps were presentations of cartographers' manual skills, and many of the old maps were extremely individual in their visualisation. Because compiling of the map was not strictly limited by regulations and specifications, each of the map had their own fonts, colours, symbols and contents, which could almost be anything that each particular cartographer wanted to use or communicate to people.

Computer aided map production and the use of Geographical Information Systems (GISs) made the map production automatic in 1960's – 1980's. Emerging Internet solutions during last decades allowed also non-cartographers to receive maps relatively quickly via Internet. This mass production also made map's visualisation less individual, since the same maps were either copied mechanically or printed straight from the database.

The latest developments include geospatial services, from which map data can be delivered to the users' mobile devices (cell phones, Personal Digital Assistants (PDAs) etc.) in real-time, see Fig. 1. During the first stage of providing maps to mobile terminals, the fastest way was to use the same map data as for desktop and Internet applications. The main problem is, however, the presence of totally different usage situations. Maps on mobile devices are also used in field situations, which means that their visualisation should be totally different compared with indoor situations on office desktops [11]. Small displays and other device properties also set many new limitations, as well as advantages.

Despite the techniques, or the decade of map-making, the basic problem in map reading has always been how well the map is perceived and understood by the user. User may not understand the visualisation of the map, the meaning of the symbols, or the purpose of the map content. Every time there is a disconnection between the map and the map user, the user has to look at the map legend, and seek for the meaning of the symbol. This causes an interruption in map reading process, and especially when being repetitive, it can have frustrating effects on the use of the map.

Fig. 1. Modern map services are capable of delivering map data to the users' mobile devices in real-time.

Compared to traditional paper maps, the dynamics of the maps on mobile devices may, however, provide some novel ways to prevent unwanted interruptions during map reading process. Therefore the problems and solutions for the interruption during map reading process are studied here from the point of view of the mobile map user. Firstly, the meaning and definitions of the interruptions are studied and the map reading process described. The paper continues by describing interruptions during the map reading process. The third section presents some examples on implementations of how to prevent these interruptions by context awareness of the mobile maps. Finally, the paper ends with a discussion and conclusions.

2. INTERRUPTIONS AND MAP READING PROCESS

Since interruptions have an apparent influence on human efficiency, many researchers have recently studied the affects of the interruptions in HCI (e.g. [1], [4], [9], [13]). The web dictionary [21] defines an interruption as "some abrupt occurrence that interrupts" or "a time interval during which there is a temporary cessation of something" or "an act of delaying or interrupting the continuity". Such an example as "the telephone is an annoying interruption" is given, which already describes the often negative nature of an interruption for the primary tasks. However, some interruptions are beneficial, because they may maintain the level of interest of a user during a monotonic work. According to Speier et al. [20] interruptions facilitate decision-making during simple tasks and inhibit it, when addressing complex tasks.

In general, it could be said that using a map is a likely situation for many kinds of interruptions. The factors that cause interruptions in map reading situation, are divided into two categories in the following:

1. External Factors

In many cases maps are used outdoors, and at the same time when reading the map, the user has also other tasks to consider. He might be walking at the same time when reading the map, so he has to look around every now and then. If he stands still, he still has to look around, when for example trying to localize himself: "Is that the same building that is presented here on the right corner of the map?" Moving in outdoors environment brings many other unpredictable aspects to the context, like voices and different peoples around the user, vehicles, etc. These may cause interruptions that are difficult, if not impossible, to prevent.

2. Internal factors

Also the layout, symbols or the contents of the map may cause interruptions while the user is trying to interpret the map. This is due to the misunderstanding, or not understanding at all, the visualising components. These interruptions are unpredictable and usually it means that the user has to look at the legend of the map. This can be irritating and time taking, especially if it happens many times.

Our earlier experiments in field-testing of mobile maps showed that the users had problems in understanding the traditional map symbols [11]. Therefore in this paper, we focus on the internal factors causing the interruptions, instead of external aspects during map reading. In the following the basics of the map reading process are described, followed by description of interruptions from the map reading process's point of view.

2.1 Map reading process

Map symbols' graphical design is composed of visual variables; size, value, texture, colour, orientation, shape [2]. By changing these we can make the symbols more or less distinctive. Due to the visual nature of the science of cartography, the underlying principles of graphic communication are critical to good visual over-all composition of a map.

People also react differently to visual stimuli than they do in written and spoken communication [15]; spoken information is received in serial fashion, that is, the words follow each other in sequence in a definite order. But with graphics, people receive visual information synoptically, all at once, instead of sequence. That means, that every map symbol is affected by its location and appearance relative to all the other symbols. Therefore the graphic displays can be seen structurally: some marks look more important than the others, some shapes will stand out, some things will appear crowded, some colors will dominate etc. [15]. Also the laws of perception [14] are strongly related to the map reading process.

Map reading process is a subjective experience, but still it is a challenging aim of the cartographer's, that everyone who reads the map should understand it, in the way, that it is meant to be understood by the designer. Cartographer's main objective in map design is to evoke in the mind of a user an abstraction of the real world appropriate to the map purpose. The final result depends, not only from the cartographer's, but also user's skills and ways to perceive, as well as from the map usage situation.

2.2 Interruptions during map reading process

When all the map elements are presented in a way that the layout meets the knowledge and the semantic models of the user, the delivered message of the map is equivalent to the message of the cartographer's. But every time the user does not recognize or understand map symbols or the overall visualisation, an interruption in map reading process occurs. Traditionally, the legend of the map helps the user to understand the map, but it is not always enough. Even if the explanation of the map symbol can be found from the legend, there is still the task to go back to the same place on the map where the interest was before the interruption. This searching can be time consuming and frustrating for the map user.

Users' map reading behaviour, and habits to search the meaning of the symbols from the legend, have been studied e.g. by Brodersen et al. [3]. They were applying eye-movement tracking of the users in searching for methods to evaluate map reading, map design, and the usability of maps. Brodersen et al. report that the users had longer fixations during more cognitive processing, and the longer these fixations were, the higher was the level of complexity of the map.

Shannon and Weaver [19] first introduced the communication system in the classical Shannon information theory, which has been referred by many researchers in computer science and in cartography as well. Kolacny [7] has presented a map communication model, where the overall reality includes both the reality presented in the map and the reality of the map user, see Fig. 2. Lindholm and Sarjakoski [8] further applied Shannon's theory in designing a query interface for a GIS.

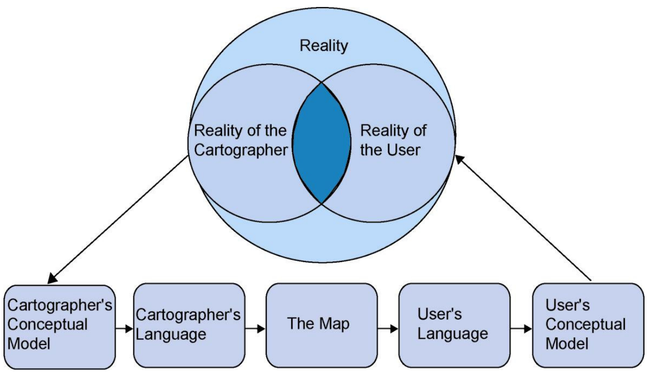

Fig. 2. Principles of the map communication model by Kolacny [7] (picture redrawn by the authors).

If there is a failure during any of the parts in the process, an interruption emerges. In an ideal situation the legend of the map would be useless and the user would understand all the symbols shown on the map and all the visualisations used to describe the reality. But in a real map usage situation, this is normally far from the truth. Normally you go to a foreign city and get a totally new kind of visualisation of the area. Therefore it is very usual, that when we get a new map to look at, we have to use the legend, since we are not familiar with the symbols on the map.

Sometimes users think incorrectly that they are familiar with the meaning of the symbol. This is even more critical to the map reading process, and can cause severe difficulties and frustrations of the user. Interruptions can also easily lead into dangerous situations, e.g. when using maps on mobile devices during car navigation and not understanding the symbol or the traffic sign, which is presented to you in a foreign country, and driving at the same time. An interruption in a driving situation can also take a lot of memory and task handling capacity, with possibly dramatic consequences.

3. PREVENTING INTERRUPTIONS BY PERSONALISATION

It is suggested in this paper that one way to reduce interruptions in map usage situation is the personalisation of the mobile map services. The basic assumption is that if the map service knows enough from the context of the map usage situation, the map delivered to the user can be adapted to the context so that the user gets exactly such a map, which is suitable for his usage situation [10]. By having the "right" map with suitable symbols and easily understandable layout in hand, interruptions during map reading could be significantly reduced.

Based on the earlier results from the user tests [11] there seems to be a clear need for context awareness in maps on mobile devices (Sarjakoski and Nivala [16]; Nivala and Sarjakoski [10]). The map is always strongly related to usage situations in which the user tries to find his/her way in an unfamiliar environment. The location of the user is the most obvious context information needed, but also several other context elements seem to be relevant for the use of topographic maps on mobile devices. In Fig. 3 the different contexts relevant for mobile map usage situation are illustrated.

In the centre of everything is the user: *Who is he? What is the way of the transportation he is using? How old is he? Does he have some physical constraints?* The purpose of the use is also important: *Is the user just wandering around in entertainment purposes, or is he going fishing?* His location, and direction of the movement, are also relevant, as well as the physical surrounding around him: *Is the weather sunny? Are there many hills on the way to his target? In which kind of cultural environment does he exist? What is his social situation at the time?* And finally: *What kind of a mobile device does he have?*

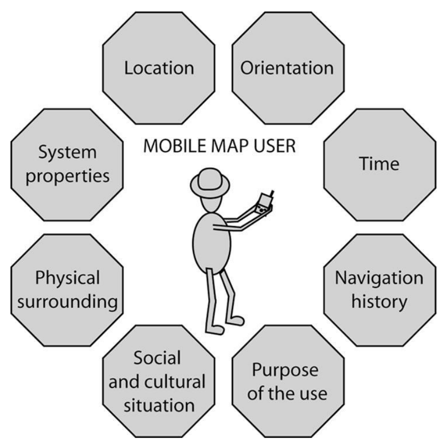

Fig. 3. Surrounding context of the mobile map user is composed of different elements [17].

The surrounding context defines, what kind of map the user wants and needs. The user should not feel frustrated or stupid when trying to understand the map. He needs maps also at different scales, and they should provide comprehensive information in various formats to various types of devices. Even a small change in map content and adaptation to the surrounding contexts can improve the usability of the map, and make the user satisfied, by preventing unnecessary interruptions.

In order to gain experience on benefits of maps suitable to user's context, an effort was made to implement context-aware maps. The technical implementations are reported by Sarjakoski et al. [17]. In the following section, only the main characteristics are presented, in order to demonstrate, how interruptions could be prevented by personalising maps for the users in different kinds of usage situations.

3.1 Preliminary context-aware map implementations

The implementations presented here are part of the EC-funded project "Geospatial info-mobility service by real-time data-integration and generalisation", GiMoDig [5]. The overall purpose of the GiMoDig research and development project is to improve accessibility and interoperability of national topographic databases. In the project a prototype for a cartographic map service has been built which delivers geospatial data to a mobile user in real-time. The data is delivered from the geodatabases in participating countries, where the common interfaces are based on XML-coded (Extensible Mark-up Language) data delivery and OGC's specifications (Open GIS Consortium). Finally, scalable vector graphic (SVG) maps are displayed on users' mobile devices (Sarjakoski et al. [18]).

3.1.1 Personalisation

The implementation of the context-aware system was built up by personalisation [17]. Maps are delivered to the users' devices in real-time, according to the personalisation that the user makes:

1. A choice of the use case
2. Identity (language, age group)
3. Time

The choice of the use cases refers to the situation where the map is going to be used. The user has a possibility to choose among a set of use cases: Outdoors, Cycling, Emergency and Expert use. If the user is going hiking, he can e.g. choose the Outdoors option, or if he is cycling in a strange city, he may choose the option that delivers a map specially designed for cyclists. The user interface is adapted in real-time to include the user's favourite use cases.

Tab.1. Examples of different symbols for different age groups.

POI type	*Generic*	*0-17*	*18-45*	*46-*
Swimmer				
Hiker				
Ice Fisher				
Camp Fire				

Personalising the service according to *the identity of the user* includes two different sections: choice of the language and choice of the age group. The choice of the language reflects to the language of the user interface itself. The choice of the age group in turn reflects to the requested map's layout, since different age groups are provided with different symbols, and therefore satisfying some special user needs appropriate to certain age group. Examples of the different symbols for different user groups are shown in Tab. 1.

The user also has a possibility to define *the time* by selecting a season of the year. He may be interested to see, how the same place looks like during different seasons. If no specific user preferences are given, the default time is always the current time.

These features in personalisation (use case, language, age group and time) response to the mobile contexts described above, Fig. 3: purpose of the use, location of the user, physical surrounding, social situation user properties and time. However, the user is not forced to define the user preferences if she/he so wishes; in that case the application uses the default parameters.

3.1.2 Examples of maps with different symbols

In order to illustrate, how the system responses to personalisation of the user properties and context of use, two different maps are presented in Fig. 4. The use case is defined as "Outdoors". The age group and the season chosen vary between the two maps. The map on the left is a summer map for age group 18-45 and the map on the right is a winter map for the age group 0-17.

Fig. 4. Maps of the same area for different seasons and for different age groups.

In Fig. 4 the most obvious difference between the two maps are totally different symbols. The idea is, that by providing the different users the right kind of symbols, the amount of the interruptions in mobile map reading could be decreased, since the users would more easily understand the meaning of the symbols.

The symbols on the left map are made for experts, who are familiar with the formal map symbols. Note, that the symbols are transparent, thus hiding as little of the background information as possible. This is very important, since the maps are provided on a small screen of mobile devices and there are already problems of showing enough of the map. On the contrary, the older users would have high demands on the visibility of the map symbols, from which it follows, that transparent symbols are not adequate. We have tried to solve this by increasing the contrast and size of the symbols for their age group, see the last column in Tab. 1.

For the young people, the formal symbols may not be so familiar, so more illustrative symbols are designed for them, to match better how they perceive the world. But it must be remembered, that the matter of the symbol sets is also a matter of subjectivity in many cases.

A photo realistic presentation style has been used for visualisation of the maps. The topographic map data received from the map service is displayed in vector format, and the Points of Interests symbols (POIs) are shown on the top of the topographic data. Additionally, a background raster image “snow” for the winter map and “grass” for the summer map is added locally in the PDA. This is done in order to match the user’s situation better and therefore help to find the link between the map and the real surrounding of the user.

There is an apparent danger of the information overflow when providing a map on the small screen of a mobile device, which can also cause interruptions. Therefore also the map content is significantly adapted to the current season, by leaving out the information that is not relevant for the current season, Fig. 4. In the summer map on the left, the hiking tracks are shown, while in the winter map on the right the user is only interested in the skiing tracks. The tracks for hiking and skiing are partly differing from each other. Fishing in wintertime and swimming in summertime are also illustrated with different symbols in order to give more illustrative presentation to the user. Notice, that during the summertime there is café open at the area, where as in wintertime it is closed and the symbol is not shown on the map.

3.2 Discussion

The two maps presented in Fig. 4 are an example of the over all idea of preventing the interruptions in map reading process by adapting maps for different users in different map usage situations. With these two examples we have illustrated that by changing just a few personalisation parameters it is possible to produce an amount of various maps. And it is not only the symbols that can change their color, size and style, but also the contents and the over all visualisation and layout of the map. It is supposed here, that as soon as the map visualisation can be adapted to the individual user needs, also interruptions during map reading process could be decreased. By providing the user with intuitive map symbols, the need to use a legend could also be decreased.

Some features of possible flexibility of the mobile map services were described briefly in the previous paragraphs and it was noted that the situation is significantly different compared to the production of traditional static paper maps. However, it must be noticed that at this point of the research the symbols created have not yet been tested with the users. Therefore particular recommendations of the map visualisation are not yet given here. The focus was on illustrating the potential of the map services, which can utilize the context information for creating different maps for different map usage situations.

Though the importance of designing the future map symbols for mobile devices seems a promising way for giving every user such a map he needs in a specific use context, there are still many things to consider. Especially, user tests are needed in order to provide the user with such a presentation that would attract him among a lot of alternatives. What are the right symbols for each user (e.g. age group), and how to make sure that changing the symbols does not confuse the user even more?

It must be considered too, that it may not be only beneficial to have a context-aware map system, which always brings you a suitable map. Sometimes adapting to a context in the way that the user does not comprehend the reason can also cause an interruption itself. Because the intelligence in the current GiMoDig prototype is based on personalisation that is made by the user him self, it is also a question to be studied, whether the users are willing to do this kind of personalisation in a real life situation. Therefore studies, on how to move this context information gathering more to the server’s responsibility, are also challenging tasks.

4. CONCLUSIONS

Users need various types of maps in different situations and when usability of maps is concerned, one of the main challenges is that the user has a suitable map adapted for the specific usage situation. In the paper the context awareness, based on personalisation of the mobile map, was studied as a one way to prevent unwanted interruptions during user’s map reading process. It was thought here, that by delivering every user with the right kind of map, with suitable symbols and layout adapted to the usage situation, interruptions during the main task, map reading process, could be reduced. However, the user tests are planned to take place in the near future, where the presented implementations are to be evaluated with the real users.

It is thought here, that though in earlier times the responsibility of choosing a right map was user’s task, in the future the right kind of a map is provided to user by intelligent map service. This is due to the new situation with the mobile contexts and the dynamics of the maps on mobile devices, which may offer some novel ways to prevent unwanted interruptions in the mobile usage situations.

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