

CONSISTENCY IN MAPS WITH ALTERING SCALES - A CARTOGRAPHIC EXPERIMENT BY THE USE OF MOBILE PHONES

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ABSTRACT:

Today it is common that upper end mobile telephones (smartphones) include maps and navigation systems. New hardware technologies for presenting maps require development in cartography. To define rules and methods for cartography on such small displays it is useful to study how people comprehend the maps on their mobile units. This paper discusses how mobile phones can be used as means for cartographic experiments. A prototype application for the study of abrupt change in colours when zooming out is introduced, and the methods are compared to similar experiments for Web-map applications.

1. INTRODUCTION

For hundreds of years geographic information was mainly stored on "robust media" like parchment, skin, paper etc., and the development of cartography was mainly related to other factors than the medium type. Today geographic information is represented in a digital database, and over a relative short period the presentation media for this information have evolved quite rapidly. Over the last ten years the World Wide Web has become the most important channel for the distribution of maps. As a fast growing supplement to this the use of maps on small mobile units has become very popular the last years. According to Meng (2005), handheld mobile devices have already exceeded traditional PCs in number several years ago. Because mobile phones are cheaper than PC's most new users today are connecting through mobile devices with tiny screens (Peterson 2007). Even though there are many similarities between maps on Web and smaller mobile units, mobile phones will always have differences in comparison to the desktop computers (screen size, interaction, capacity etc.) (Kenteris et al. 2008).

Some years ago the most relevant units for mobile map use were different kinds of PDAs (Personal Data Assistants). Clarke (2004) discusses the thin/fat client issue and the capacity for GIS software and GIS operations on mobile units at that time. Today the use of maps on navigational equipment for land vehicles has exploded, and it has become common to include maps and GIS operations on mobile telephones. Accompanied by a Global Navigation Satellite System (GNSS), usually Global Positioning System (GPS), these have become very useful as navigational aids. Earlier navigational use of small handheld equipment was limited by the lack of computational and storage capacity. Today this is a negligible problem. The most common GIS operations can be handled by the units, and adequate maps can easily be stored in the in the built-in memory. And the trend is that the capacity of these hardware components is increasing steadily. Hence, mapmaking has become ubiquitous and the cartographic community need to rethink traditional bounds of scale, content, context, media and use (Gartner et al. 2007).

With respect to cartography, the screen size and the screen resolution are important factors. Even if the screen resolutions on mobile units have improved considerably over the last years, and it is a fact that the screens on new mobile phones have grown, there is a limitation on how big a conventional screen might be on a mobile phone. The units are supposed to be carried in a pocket, so people do not want this kind of equipment to be too large. Seven years ago Nissen et al. (2003) indicated that a "good" screen for mobile phones would offer colour display with a size of around 180x180 pixels or more, ..and that 360x360 screens were not considered as small displays! Today the high end "Smartphones" includes screens at a maximum of 3.5 - 4.0 inches with the resolution 360x640 - 640x960. Until we get some kind of very thin "fold-away" screens, like the e-paper described by Gartner et al. (2007), one can not expect a considerable increase of the screen sizes. When it comes to cartography for small screens, Dilleuth et al. (2007) states that research has not kept pace with technology, and so far rules and standards for cartographic presentations on small displays have not yet been defined (Gartner et al. 2007). There are several points of distinction between using a map application on the Web and using a corresponding application on a mobile unit. Screen size is one of the most obvious one. However, there are also many similarities, especially when it comes to the server-side operations. Thus it is natural to draw some parallels between doing experiments on web and performing similar experiments on mobile units.

2. TESTING THE USABILITY OF MAPS

The large map providers on the Web have most likely quite extensive log routines for all the use of their maps. From these data they will be able to detect some of the users preferences during their map viewing session. This information can help in the development of the next version of their map application. However, when it comes to the study of particular cartographic details, and how these are perceived by the map users, the logged data may be too coarse. To answer more fundamental

cartographic questions one need more controlled experimental applications which are dedicated for the particular cartographic tasks. Usually such studies are carried out in laboratories to keep the environment factors equal for all the participants in the experiment. On the other hand, Spyridakis et al. (2007) argue that Web-design guidelines should be given by research conducted in natural settings. Accordingly, cartographic applications on Web should be investigated through experiments in their natural environment: namely using the World Wide Web itself. Van Elzakker et al. (2007) also argues that usability testing of mobile geo-applications cannot be properly checked by means of controlled laboratory experiments alone. Despite this, it is quite common that this type studies are carried out in laboratories only.

In their work van Elzakker et al. (2007) introduces a methodology for testing the usability of mobile maps. This involves a detailed study on how people behave when they are using the mobile units. Similar research was carried out by Dillemath (2005). Both these experiments are based on a close follow-up of the participants. Hence, the number of subjects will be quite limited. Birnbaum (2004) points out that the Web opens for large numbers of responses and a much wider participation than the typical small group of students usually involved in experiments at universities. These are important motives for several examples on psychological research conducted on the Internet (Psychology Experiments on the Internet and The Web Experiment List). The Web can be used to reach certain groups that are wanted for the experiment, and when there is an extensive attendance the participants can be divided into smaller, more specialized groups.

Cartographic experiments for Web use can be introduced on several levels. The simplest approach will be to use standard Web-survey tools where figures can be combined with some kind of html-forms. There exist several standard research tools for this use, where the selection and succession of the introduced data sets or test conditions are handled in a balanced and systematic way. However, when it is desirable to measure the users interaction with the map in details it might be necessary to implement a special application adapted to the problem. Midtbø and Nordvik (2007) introduces a such applications where coordinates for selected points in the map are measured and stored in the database for the collected data during the experiment. For time studies, when response time or the time used for certain operations in the interactive map, the system has to be prepared for a deeper interaction between the map application at the client and the server side application and database.

3. SELECTION OF SCALES IN MAP APPLICATIONS

When the Web was introduced about fifteen years ago the "first generation" of Web maps appeared as scanned versions of the existing paper maps. It became quite obvious that the cartography intended for common paper maps did not meet the requirement for the presentation of maps on the Web. Quite soon new series of maps that were better adapted to the Web media appeared. Detailed maps that cover a large area need to be available in several scales, and the next generation of Web maps provided series of maps where each scale was pre-made and were the user could get an image-file of a selected area in a selected scale. Zooming in and out of these maps had necessarily to appear as a stepwise operation. At the same time several experimental Web-sites where the user could select

themes and design his/her map showed up. In these kinds of applications the client typically did some simple selections through a HTML-form, sent a request to a server which produced the map and returned it as a image file. Later Open Geospatial Consortium introduced Web Map Service (WMS) which offered a standardized way to transfer geo-referenced image files and combine different layers in a map application in the browser. Usually a zoom in/out operation in a WMS application appear in a stepwise manner. However, the experimental map application at BeeldBlad uses Flash technology to make a smooth zoom in a WMS-based application.

During the existence of the Web numerous map applications have been introduced, and many of them have included dynamics. The last category do often focus on selected phenomenon. However, the more general maps like Yahoo maps, Google maps, Live Search Maps, MapQuest, Google earth etc., dynamics are limited to animated (smooth) zooming and panning operations. Some of them have also included a smooth tilting movement. Looking on the zoom methods in particular, the tendency over the last years has been towards a dynamic selection of of object at different scales, and better consistency in the cartography when moving from one scale to another. While most map applications provides a smooth movement when panning the map, zoom operations often appears in a stepwise manner. Large map providers like Navteq, Yahoo and MapQuest still offer the stepwise zoom, while for example Google Maps and Live Search Maps have implemented a smooth animated zoom. Midtbø and Nordvik (2007) indicates that it is easier for the map user to follow the geographical content of the map if a zoom operation appears as a smooth transition between different scales. Abrupt changes in the maps seem to confuse the map users.

For mobile users there are other considerations that have to be taken into account. Dillemath et al. (2007) give an overview over combinations of speed, position, scale and cartography on six personal navigation systems. Their conclusions are that there is high variation in terms of the number of available zoom levels and map scales at each zoom step. Li and Ho (2004) also points out the benefits of, at certain scales, to highlight map objects within a buffer zone around the actual position of the mobile unit.



Figure 1. Abrupt change in colours when zooming out one level.

In March 2008 Nokia introduced Nokia Maps 2.0. for their mobile phones. This application includes smooth movements both when panning and zooming in the map. However, when zooming in and out of the map some areas have a considerable variation in the colour. Vegetation appeared at a certain scale

represented by a dark green hue (Figure 1). Even if the zoom operation itself is smooth there is an abrupt change in the map image. This is not an unusual phenomenon. Several maps on the Web have an abrupt change in the content when moving from one scale to another. Since it is indicated that smooth transition during zoom is better than abrupt changes in a stepwise zoom (Midtbø and Nordvik 2007) it can be interesting to have a closer look on how abrupt changes in the map content influences the comprehension of the geographic content during the zoom.

4. PROTOTYPE FOR MOBILE PHONE EXPERIMENT

When it comes to maps on mobile phones, and taking into consideration Spyridakis et al. (2007)s observations about conducting the research in a natural environment, it is interesting to take a closer look on how the comprehension of the cartography can be investigated on the actual unit. This section describes a prototype for an application for cartographic experiments on mobile phones and compares this to corresponding Web applications.

4.1 Technical solutions

Over just a few years mobile phones have developed from "simple" communication tools to small multimedia computers. Today it is hardly possible, even on the cheapest models, to get a mobile phone without for example a digital camera. Like in other electronic hardware memory and computing capacity are increasing for each new model, and in addition to platform specific applications, most higher end mobile phones can handle Java/Flash/SVG (with some exceptions for iPhone!). This makes it possible to implement applications independent of the operating system on the actual units. It is also a fact that Java or Flash software are well suited for easy implementation of small map application for distribution by the Web or mobile units. Especially when the application includes some kind of animations.

An application for cartographic experiments relies on network connections for systematic distribution of map samples and for the collection of results from the experiment. And communication is still the main task for a mobile phone. Systems like for example GPRS (General Packet Radio Service) and WLAN (Wireless Local Area Network) can be used for data transmission between the client and the server (Herstad 2007). While a full map application may have to download maps of new areas by standardized data formats, an application for an experiment can be handled in a simpler way. Some predefined graphical files have to be downloaded by request, and the resulting data can be returned as single variables. Both Java and Flash are prepared for this kind of communication.

On the server side we need an application to handle the requests from the mobile unit, and we need a database for storage of the results from the experiment. For the examples described in this paper PHP is used as the server side application. The free available scripting language PHP, which was originally designed for producing dynamic Web pages (Wikipedia:PHP), is well suited for the communication between the application on a Web or a mobile client and the server side database. PHP is often accompanied with the free available database MySQL, which makes a natural choice for the storage of collected data and necessary parameters to run the experiment.

On the client side this project uses Adobe Flash CS3. Unlike our server side applications this is a commercial software. However, it is well suited for the implementation of animated graphics and it includes tools for making Flash Lite applications. These are Flash applications which are intended for the use on mobile units. The last version available on mobile phones today (August 2010) is Flash Lite 4.0.

4.2 Application for experiments

The "cartographic background" for the this outlined experiment is the fact that several Web-based maps and maps on mobile units have a rather abrupt change in colours when zooming between different scales. How may this influence the users recognition of the map during a zoom operation? For the selection of maps for the experiment certain conditions had to be met:

- In the same area: The existence of two series of maps with different colour variation during a zoom.
- Possibility to choose areas with different characterization.
- Unknown areas for most of the participants in the experiment.

Maps with dissimilar colour variation may be custom-made for the experiment. A such approach makes it easier to present two clear alternatives. However, in the initial phase two existing "map series" were chosen. The maps at the Web sites for "Yellow Pages" in Norway (Gule sider) and Sweden (Eniro kartor – Gula sidarna) have differences in the cartography but seems to be based on the same data set for Sweden. And by choosing different areas in Sweden it is most likely that Norwegian participants in the experiment are unfamiliar with the local geography.

For the experiment, map samples from five areas with different characteristics were selected. In the map applications on the actual Web sites all zoom operations worked in a stepwise manner. To make a smooth zoom for the experiment, maps at different scales were saved and included in a Flash animation. These map animations became the fundamental elements in the experiment application, where the participant were requested to follow a selected geographic location when zooming out of the map. For the participants the experiment appears like this:

1. A welcome display which informs about expected time use and that the response to to the application will be recorded.
2. A display giving more details on what the participants are expected to do.
3. Two "warm-up" exercises working identical with the following experimental tasks
4. The two experimental zoom animations from different areas and by different cartography. Each of these are:
 - First presenting a large scale map where a certain location is indicated with a red circle (Figure 2)
 - When selecting the "zoom out" button the red ring disappears and the map zooms out. The participants are supposed to follow the selected site.

- When the zoom ends three alternatives for the indicated site shows up in the small scale map. Each participant is supposed to select the one he/she think is correct (Fig 2).

- At this point it is possible to inform the participant if he/she did hit the right site or not

5. A display asking some general questions about age, map experience etc.
6. A display that opens for general comments to the experiment
7. A display showing gratitude for participation in the experiment



Figure 2. Left: before zooming out. Right: after zooming out.

Two "zoom out animations", based on the two cartographic styles, were prepared for each of the three different areas in the experiment (two of the areas were reserved for the warm-up exercise). In addition to the "warm-up" animations each participant was only exposed to two animations, one in each cartographic style. To provide data material for further analysis it is desirable to use an even distribution of the various map samples. Consequently, the data base is consulted in the beginning of the experiment and information about the least used animations/successions are returned to the Flash application. In the end of the experiment all the choices made by the participants are transferred to the data base.

4.3 Experiments on mobile phones versus Web

Midtbø and Nordvik (2007) describes a Web-based experiment which compares "sliding zoom" and "stepwise zoom" in a map application. In that experiment the participants are following a geographical site during the zoom in/out operation and are requested to indicate the site with a mouse pointer. On an ordinary mobile phone the possibilities for interaction with the application is more limited than in a similar Web application. The "pointing unit" on a standard mobile phone can be compared with only using the arrow keys on the keyboard. Smartphones with touch-screen technology open for some wide possibilities here. Generally people tend to be quite impatient

when using the Internet. Consequently, applications for experiments have to be simpler than if the same experiment is arranged in a laboratory. The running time need to be short and the tasks have to be clear and unambiguous. It is no reason to believe that people are more patient when using an application on their mobile units. And because of less facilities for additional instructions the tasks have to be even more unambiguous. The following list indicates some consideration when moving an experimental application from the Web to a mobile phone environment:

Limited pointing device The use of mouse pointers are more cumbersome. Selection between a limited number of alternatives can be handled more easy. Touch-screens open for more possibilities.

Bandwidth The channels for communication will often be more limited than for a Web connection (for example when using GPRS). Consequently, the application should be as small as possible.

Price When not using WLAN there is usually an expense based on amount of transferred data. An indication of the size of the application (in Kb) will be of interest for the participation.

Screen size The visual appearance of the application has to be more compact because of a limited display. Instructions have to be short and straight to the point.

Compatibility Different mobile phone brands and types have different operating systems and screen resolutions. At the moment many standard phones are limited to about 320 x 240 pixels for their screen resolution. On new smartphones this resolution can be doubled. In this project Flash Lite is suggested to make the application available on various operating systems.

Control buttons Control panels etc. will cover a relative large part of the display, and if there are many buttons they will be a little more cumbersome to reach than when using a mouse pointer on a PC screen. Except for the general questions in the end, the described experiment had only one selection on each display (choice between three alternatives on one display, hit the next button on the next display etc.)

Open ended question Comments from the participants may be very interesting and useful. An open ended question on a mobile phone is comparable to sending a sms and could be attractive to use for the most interested participants.

4.4 Running the experiment

Before introducing this kind of experiment for a larger group of people it is necessary to carry out an extensive preliminary studies to get an impression of how people understand the application. Results from this study can be used for adjustments of the experiment for the final "release". In our case the application was introduced to students in a classroom. A Nokia N86 8MP was circulated between the students, and each of them were encouraged to focus on the application for a few minutes during their involvement in the experiment. The intention of this pilot study was to learn how the participants did handle the application. Did they understand what to do? Was the instructions sufficient? Was the interaction with the phone understandable? To keep focus on these questions the cartographic task was made quite simple in this initial experiment.

During the session 1-2 students reported some problems on how

to use the application. This was mainly about the understanding of how to interact with the application and which “buttons” to select. Except for these minor difficulties the pilot study went smoothly. All together 15 students completed the experiment. 3 different dataset (different areas) were prepared for each “map series” (animation). Each participant was exposed for both of the animation types, but for different data sets in each animation. As a consequence of the quite simple cartographic task no significant difference could be detected between the two animations. In fact, only 4 out of 30 tasks resulted in a wrong answer.

In the next phase of the experiment the intention is to adjust the degree of difficulty and present the experiment for a new group of participants. Unfortunately, due to some problem with the mobile equipment this part of the experiment could not be carried out in time for the deadline of the paper.

To get response from large groups of people it may be necessary to make the experiment available both on the Web and on mobile phones. An identical version of the application (same resolution, same displays) prepared for Web can reach a large groups of participants, while a smaller groups of people using the phone application can help to detect differences between the two applications. When running the experiment it is possible to reach many people and to collect large amounts of data. During the experiment, when the amount of collected data is sufficient, it is possible to set focus on other research issues by changing some parameters in the application (for example faster or slower animations).

The mobile phone itself showed up to be a perfect tool for the preliminary studies. It is easy to bring, and the application can be presented to different people wherever you want. It is necessary to make notes of the comments from the “preliminary participants” while their results from using the application will be stored in the database. Using the mobile phone is much easier than presenting a similar study on a laptop.

4.5 Conclusions and further work

Hardware technology for displaying cartographic presentations has been changing rapidly over the last years, and cartographic research need to keep pace with this development. Lately it has become very popular to include maps on mobile phones. To learn more about the usability of maps on these small screens it is interesting to develop methods for the study of how the users comprehend the cartographic content. This paper presents a technical framework for how to run such experiments in a natural environment; the mobile phone itself. This introduces some new challenges compared with similar experiments on the Web. A prototype application for an experiment on mobile phones have been implemented and tested, and some pilot studies have been run. However, a full scale experiment has not been carried out at the deadline of this paper. The next step will be to adjust and improve the cartographic tasks in the experiment and introduce this to a new group of participants. The plan is also to make a new version of the application where the interaction methods are adapted to touch-screen telephones.

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