Geo-referenced Information Visualization on Mobile Devices

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Abstract

The number of mobile devices and associated services has recently been growing considerably. This growth has been changing the way people access information. The technological advances of mobile devices offer new opportunities to areas where geographic data has an important role. PDA, mobile phones and other portable devices are increasingly beginning to have location awareness via GPS devices. These continuous improvements have made possible to incorporate graphic visualization applications to show relevant points of interest to the user without extra actions being necessary. However, usability aspects of this interaction need to be correctly studied to persuade users to accept these visualization applications. Furthermore, mobile devices have several limitations when compared to desktop computers and as a consequence visualization applications developed for the desktop cannot be easily ported to mobile environments. Limitations on the screen size restrict the interface area and the number of data elements that can be displayed. Additionally, limitations on the memory size, processor, graphics hardware and connectivity further reduce the performance hindering the development of complex applications. In this paper we describe an ongoing research that aims to design solutions for the visualization of geographic data on mobile devices. An initial research on similar applications has already been done and as a result the architecture for a geo-referenced visualization application has been defined. In the future, a prototype based on this architecture will be developed which will allow us to test different visualization techniques, filtering mechanisms and adequate representations for the users search results.

Keywords

Geo-referenced Information, Mobile Devices, Visualization, Usability.

1. INTRODUCTION

The number of mobile devices has been increasing drastically. According to a study from Gartner, Inc.[1], worldwide shipments of PDA's and Smartphone's combined totalled over 42 million units in the first half of 2006, which equals a 57 percent increase from the same period in 2005. This growth, in association with the increasing number of services available through these devices, has been changing the way people access information. Indeed, it is almost certain that in the near future, the most common method of accessing information is through these devices, even by people who have never used a computer before [Chitarro04].

People frequently make use of visual tools such as maps, graphics and diagrams, to better understand and rapidly resolve certain problems. The continuous advances in the computational power and graphics processing have made it possible to include an extensive array of visualization techniques in most domains, including business, engineering and science [Chitarro06]. On the other hand, the evolution of mobile devices offers new prospects in domains where geographic data have an important role, such as cartography, tourism, natural resources management and emergency management. These devices allow the user to access geo-referenced information in real time, anywhere and anytime, in a dynamic and flexible way [Burigat05]. Since it is estimated that 85 percent of information has a spatial component [MacEachren01], the potential of obtaining geo-referenced information through mobile devices is rather promising.

Presently, it is common to find mobile devices with a built-in GPS device. This allows the mobile device to automatically obtain the user's position, instantly presenting to the user a map including local points of interest, without the need for any further action. The user is therefore allowed to perform numerous tasks, including finding relevant locations in the vicinity, such as a gas station, the nearest ATM machine or calculating the shortest way to a certain place. The use of maps

[1] http://www.gartner.com/it/page.jsp?id=496997

Gartner, Inc. Gartner's PDA and Smartphone Quarterly Statistics Programme.

allows the user to compare alterative locations, such as the location of a restaurant, helping the user to perceive its distance from the user's current location, and also if it is in the neighbourhood of other locations that the user wants to visit.

However, to make possible the previous scenarios, it is necessary to explore the usability of such systems. Inexperienced users will not adopt these devices enthusiastically if the complexity and burdens of the limited interaction are not removed [Chitarro04].

Therefore, it is fundamental to employ efficient visualization mechanisms that guarantee a straightforward and understandable access to relevant information to allow the user to accomplish his tasks. An approach to successfully visualize spatial information and the related non visual information is, thus, an important research topic [Burigat05].

The objective of this work is to analyse the problems of geo-referenced information visualization through mobile devices and to present some proposals and solutions. Some research has already been done, and as a result an architecture was defined for the future development of a prototype to test the different visualization techniques and filtering mechanisms.

This paper is organized as follows: section 2 references some existing geo-referenced information visualization applications; section 3 describes some of the visualization limitations of mobile devices; in section 4 the defined architecture will be briefly described; finally, section 5 will present some conclusions and the future work.

2. RELATED WORK

There are already several geo-referenced information visualization tools for desktop computers, such as MetaCarta[2], Google Maps[3] and Google Earth[4]. A significant portion of the research done for these applications on mobile devices has focused on the development of tourist related applications that use the position of the user, as well as the current time, to display maps to the tourist which contain useful geo-referenced information. CyberGuide [Abowd97], GUIDE [Cheverst00], CRUMPET [Poslad01] and Lol@ [Gartner01] are examples of this type of application.

Besides the academic projects, there are also commercial applications. The majority of these are focused on car navigation systems such as the TomTom Navigator System[5] (Figure 1). However, these systems are excessively focused on the navigation task and consequently do not usually offer the best graphic quality, presenting maps with an excess of information and difficult to read. Therefore, new methods are necessary for a proper visualization of the geo-referenced information on mobile devices [Krüger04].

Figure 1: TomTom Navigator System

A new application that was released recently is the mobile version of Google Maps[6]. There is a concern to avoid the cluttering of the maps with too much detail, by limiting the amount of names and roads shown in the different zoom levels. However, this application still has some limitations. There is no way for the user to further refine his search when there is a lot of results and some of them overlap others (Figure 2). The symbols used do not convey any additional information to the user to assist him in his task. Consequently, to assist the user, filtering mechanisms and adequate representations of the results should be provided.

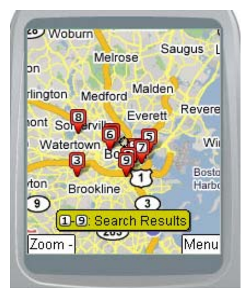

Figure 2: Google Maps Mobile

3. MOBILE VISUALIZATION LIMITATIONS

When compared to desktop computers, mobile devices have a great number of limitations that need to be taken into account when developing visualization applications for these devices [Chitarro06]:

- Small screen size, low resolutions and a small amount of colours;
- Aspect ratios frequently different from the common 4:3;
- Limited processing, memory and storage;
- Small input devices, inadequate for complex tasks;
- Different input techniques (e.g. handwriting);
- Slower connectivity;
- Wide range of different specifications according to the device model and brand.

[2] http://www.metacarta.com

[3] http://maps.google.com

[4] http://earth.google.com

[5] http://www.tomtom.com

[6] http://www.google.com/gmm

Screen size is undoubtedly the most serious limitation. Although increasing in quality, the size of mobile devices screens should remain unchanged given that the device itself has the requirement of being small. Severe usability problems derive from this requirement.

A user that is exploring a vast area will have a global perception of the location. However, he will not have enough detail about it. On the other hand, a zoomed image will provide the user with more detail, but it will loose the surrounding context, as relevant places disappear from the screen, turning a comparison between two locations a complex task. To compare the different alternatives, the user is forced to constantly adjust the magnification of the area, turning the interaction into a slow, complex and confusing task [Baudisch03, Burigat05].

Another problem is the presentation of an excessive number of results. It is necessary to reduce the quantity of represented elements to obtain an intelligible image. The results will be clearer to the user if filtering mechanisms are available. This means that fewer results should be visualized, and those which are shown are selected according to more precise criteria, including, for example, knowledge of the user's interests [Carmo05].

The mobility context, itself, is the source of some problems, since the environment is constantly changing, provoking important changes in the way the user perceives the information (e.g. changes in luminosity, communication quality/speed variation) [Chitarro06].

Consequently, visualization applications developed for desktop computers are not simply ported to mobile devices. The work presented in this paper aims to overcome these limitations by exploring the adaptation of filtering mechanisms and visualization techniques to mobile devices. They will allow users to easily access and understand relevant geographic information to support their daily tasks.

4. ONGOING WORK

Applications that use maps for geo-referenced information visualization are crucial in helping the user to obtain the required information. These applications require a friendly interface that allows the users to interactively search the information. In our work, we intend to integrate filtering mechanisms based on semantic criteria and to use multiple representations with different levels of detail to express the user's preferences.

Maps will be easier to understand if filtering mechanisms are available. Moreover, if these mechanisms allow the user to express his preferences, this will reduce the display of less relevant elements, thus obtaining a less cluttered map. The reduction of the elements displayed should be done according to measures considered important for the user. Some authors have already defined functions that quantify the user interest in particular queries. Keim and Krigel define a relevance factor that quantifies the distance of each element in a database to the conditions stated in the query [Keim94]. In [Reichenbacher04] a relevance function is defined that depends on a spatial distance, a time period and a topical distance. As a starting point, we intend to extend the degree of interest function [Furnas86] and define a generic filtering function that combines the different attributes of the information in a general and flexible way. These attributes may have different variation domains and can contribute in a positive or negative way to the final result.

An alternative to reduce the number of results displayed is to group the elements that are geographically close and use different graphic icons to express this grouping. MetaCarta, for instance, uses three different types of icons to represent documents, according to the number of documents it represents. In [Camossi03] a detailed representation is defined and generalization operators are used to derive the less detailed ones. Some authors define representations organized in a hierarchical structure that is more suitable to aggregate objects in smaller scales [Bederson00], [Frank94] and [Sarkar93]. In [Burghardt04] a similar approach is used, however, instead of graphical representations, the lower levels store the number of observations. In this work, we will start by using the approach in [Carmo05] that uses a linear representation organization. In this approach, the representation for each data element is selected taking into account the scale of representation and the user's interest. This technique requires the use of multiple representations that express variations in the granularity or detail level while conveying the semantic criterion defined by the user.

The correct position of the data elements also has to be taken into account, particularly when the items are not grouped and correspond to close geographic positions. Overlapping elements should be avoided to allow the user to be aware of all the results. In this work we intend to evaluate the existing solutions to find the most suitable approach.

After the initial research phase, we have reached a preliminary architecture (Figure 3). This architecture will be used in the development of a prototype that will allow us to test the different information filtering mechanisms and visualization techniques.

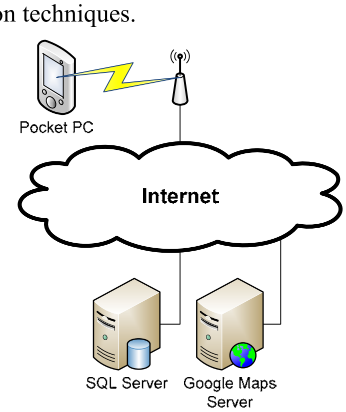

Figure 3: Preliminary architecture

The user interface will be developed for the Pocket PC, with the Windows Mobile 5.0 operating system, using the .Net Compact Framework 2.0. The client application communicates with the Google Maps web server in order to retrieve the map images for the desired locations and magnification levels. Due to the lack of documentation that exists for Google Maps, testing was needed to find the latitude and longitude variations in each zoom level. The client application will additionally retrieve data about the points of interest for the given location from an SQL Server.

The definition of the architecture was rather limited due to the difficulties that exist when developing for a mobile device. For example, the use of JavaScript map servers was not possible, since we found no browsers fully supporting this scripting language.

5. CONCLUSIONS AND FUTURE WORK

As discussed in the previous sections, it is necessary to do a considerable effort to understand how to design efficient visualizations for mobile devices. Although there are some specific techniques proposed, there is still a need for a broad discussion of visualization techniques for mobile devices.

As we have seen, geo-referenced information visualization applications developed for desktop computers, are not easily transferable to mobile devices. It is also not expectable that all of the limitations of mobile devices will disappear in the near future.

We have already explored existing similar applications and defined a software architecture that allows the visualization of geo-referenced information on mobile devices. Using this architecture we will develop a prototype to test and get an insight of different information filtering mechanisms and visualization techniques to be used. Our goal is to develop efficient methods to present intelligible information to the user, including mechanisms to allow the user to interactively define searches that express his interests.

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