Geo-info to-go

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Abstract

The mission of the Dutch grant program 'Space for Geo-information' (*Ruimte voor Geoinformatie*, www.rgi.nl) is described as "the enhancement and innovation of the geo-information infrastructure and the geo-knowledge community in the Netherlands". One of the projects (RGI-149) currently undertaken within this program is called 'Geo-info to-go'.

The main focus of this project is to ensure that the geo-information needed by field workers in relation to their physical location is automatically available and displayed on their hand-held mobile devices (PDAs). Currently, a user must type in the request for the specific information he/she needs. However, this is inefficient and very impractical on location, due to the fact that the typing might be done with one hand, in gloves and in dirty circumstances. A user doesn't have the time or capability to specify and pull the necessary information, and should thus be automatically provided with a set of relevant, appropriate, well-defined geo-information according to his/her profile, identity, location and behavior. This means having a special kind of location-aware, adaptive, context-driven supply of geo-information. The mobile device used has to offer adaptive cartography with as little user interaction as possible.

This project is undertaken in the context of the application '*Buiten Beter*' (Better Outdoors), of which the purpose is to support the surveillance of environmental offenders in cases such as garbage dumping, pollution and other misdemeanors. The work process of these inspectors is well understood, and they should be supported with a suitable set of maps, dedicated to their specific needs. This paper describes the work process into more detail, the proposed method of adaptive cartography and the interaction possibilities that can support these kinds of professionally-used location-based services.

Key words:
Location-awareness, Context-driven, Minimal user interaction, Pull-services

Introduction

Within the process of surveillance on environmental offenders the inspectors are, if they participate within the *Buiten Beter* project, supported with a special application that runs on a HP Mobile Messenger. This Pocket PC is equipped with a digital camera, GPS, an alpha numeric keyboard, and a GPRS connection. This combination makes it possible to report an environmental offence in an efficient way. The registration consists of an on-the-spot description of the kind of misdemeanor, i.e., an illegal garbage dump, combined with a photo of the offence and its position determination by a GPS fix, a more descriptive location indication like an address, or a manual indication on a map. In all positioning cases, the map is used to support the inspector with a visual feedback, as a 'dot' on the map indicates a successful report. This registration is sent to a central server and the process to fine the offender is started. If the inspector is qualified to do so, he can try to locate the offender, or he can warn the owner of the property on which the environmental offence has taken place. Otherwise, the *Buiten Beter* application will send this report to a more skilled colleague who can settle this environmental offence.

In this process, geo-information is vital; not only in the registration (what has happened where), but also in knowing the possible distribution of the pollution (i.e., poison dumped in a river, oil leaked into the ground). The access to relevant and up-to-date maps can be pulled by requests, but it will work better when this information is directly and automatically provided (pushed). This requirement means the availability of relevant, appropriate, well-defined geo-information according to the profile, identity, location and behavior. The geo-information self should be visualized such the user can proceed directly 'maps-to-act', without the need to 'read-the-map'.

As the environmental inspectors use a Pocket PC with a relative small display and limited interaction (i.e. a small keyboard and touch screen are not designed to use with one hand in gloves or in dirty circumstances) there is a need for a well considered cartographic representation and a profound utilizing of the interaction possibilities. The 'Buiten Beter' case acts a kind of general user scenario on all business cases in which Pocket PC devices and the like are used in demanding and time-critical situations.

To understand the possibilities and the limitations a literature study on cartographic representation on small displays has been conducted in conjunction to an investigation on interaction with mobile devices. The result of this desk-research is presented in the following sections. The findings will be taken into account in an improved version of 'Buiten Beter'.

Geo-info to-go: Cartographic representation on small displays

The integration of context awareness and mobile technology can be used to identify environmental crimes and raise environmental awareness. By using the adaptive method, environmental crime officers could be provided with the correct amount of geo-information. In this context the correct amount of geo-information means that the environmental officers will be provided only with information related to their profile as investigative officers and to their position. The question of how to implement this approach is the central issue behind this section.

In this study the most important methodological aspect is the time required to absorb and understand the information contained in an online map. The transmission of information depends on two factors: effectiveness, meaning the completeness and correctness of the information transmitted; and efficiency or the relation of the results to the amount of time required to obtain them. However, recent research findings have revealed the existence of a third usability factor, namely the degree of satisfaction experienced by the map user, which could be used as a benchmark for good map design.

Applying context awareness to the mobile map could help with map reading and, in addition, the navigation and the usability of the map may be improved. The set of topographic data alone will not satisfy user's needs, as the data is difficult to understand and read, especially without a legend and with the other limitations to cartographic presentation. Therefore, the solution must include both topographic data sets and more enriched information, such as points of interest (POI) and linked information sources, related to the user's surroundings. Using the context information available, the map service must also be able to adapt the visualization to different usage situations and individual user's needs.

Context awareness and adaptation are closely related, and the two terms are often used to mean the same thing. However, they refer to different capabilities. Context awareness is the capability of perceiving all aspects of the user's situation and, as a result, adapting the behavior of the system in terms of the services, data and interface. Adaptation is the ability to provide different versions of a service or different presentations of a document to suit the needs of the user, the environment, the equipment, etc. Adaptation is therefore the goal of context awareness, something which can steer context awareness without explicit intervention by the user. A context-aware application must manage the context as one of its inputs, processing any user requests on the basis of the different contexts. However, it is simplistic to consider the context as one of the items of application input data, because of the difficulty of classifying in advance all the combinations of user situation, equipment and other context-dependent parameters. Context, therefore, must be managed separately and its influence on the behavior of the application must be described orthogonally with respect to the application data.

Another important problem is the extent to which the user can be involved in the context awareness and adaptation process. This can be a very difficult type of problem. It is sometimes also highly critical to ensure that a user really benefits from the adaptive service. The user may sometimes want to be aware of, or at least to be able find out, how the system works. There are also many situations where a user may even want to choose the adaptation mechanisms which he will use. In other cases, people may prefer to be totally unaware of any adaptation process and only focus on enjoying the adaptive services.

The transfer of the general adaptation concept to the field of mobile cartography has been investigated by Reichenbacher (2004). In the mobile usage process, geospatial information is demanded by the user and visualized via a user interface. These three items constitute the objects that are adaptable to the adaptation target, in other words the mobile usage context, by applying different adaptation methods.

In mobile cartography the set of objects that can be adapted is extensive. The user interface is basically determined and constrained by the device in use. For instance, a PDA with a touch-sensitive screen allows for different types of interaction than a smartphone with a keypad. Therefore, the interaction style probably needs to be modified. The availability or granularity of the interactive map functions could also be adapted. Certain functions need to be hidden or aggregated to create more general functions. Furthermore, the interaction mode can be adapted. In other words, the interaction mode can change depending on the current function (for example, from pointer to text entry). The geographic information can be adapted in different ways. Selecting, adjusting the amount and level of detail (LoD), classifying and grouping information are all forms of information adaptation. Another aspect is the adaptation of information encoding as a result of the capabilities of devices or the constraints of the mobile network (for example, band width). However, the most important factor in mobile cartography is the adaptation of the visualization. The map section and the map scale are global objects which can be adapted in the visualization. The visualization method used, for example graphics or photo, 2D or 3D, photo-realism or abstraction, can also be an object of adaptation. For instance, a landmark could be displayed as either an abstract symbol or a small photograph. The dimension is another adaptable object in the visualization process. As in generalization, it refers to the dimension in which a feature is represented. For example, a city can be displayed as an area or a dot element. Last but not least, symbol parameters (graphical variables) and text attributes are adaptable. It is obvious that certain objects are constrained by or dependent on others. Not all of these potentially adaptable features are equally suited to adaptation.

A good understanding of how to use the general context concepts in the design of various adaptive applications can greatly benefit application designers by helping them to determine which context should be considered in their applications and to understand how applications adapt to context information.

It is clear that mobile devices have limitations in relation to the presentation or visualization of information, such as their small display size. For example, the representation of maps on a PDA is different to that on a laptop. The smaller the display, the more cartographic information is lost. In order to reduce the amount of information and ensure that it can be displayed effectively on a small device, a generalization process is one possible solution. Unfortunately, cartographers and map designers should be aware that generalization may not reduce the information content. Therefore, the challenge involves conveying the entire message whilst reducing the amount of information and ensuring that the results of a generalization process can be used by a range of different users.

The application of adaptive systems and context awareness play an important role. This should be taken into consideration when designing the application in order to provide the correct amount of geo-information to the right person at the right time. These approaches will ensure that the user has the opportunity to specify which information he really needs for his purpose. The alternative is for the user to state his purpose and then allow the system to select the necessary data and discard unimportant details. The basic concept of this approach is that if the system can obtain sufficient data about the surroundings where the map is being used and the user's current activity, then the map can be adapted to the context so that the user is provided with the appropriate or correct amount of information, suitable to the situation and the specific user. The fundamental principles behind context awareness are based on an adaptation service. It is essential to take these principles into account when designing the application that will represent the cartographic information. Integrating adaptation and context awareness into mobile devices which are to be used to detect environmental crime will form an effective starting point for raising environmental awareness.

Geo-info to-go: Interaction

This section attempts to explain how to interact with a mobile device and why it is necessary to embrace a paradigm shift in terms of interaction techniques for mobile devices that could be used by dedicated users with as little visual attention as possible to access information efficiently and effectively based on their profile, identity, location and behavior.

Users are typically in motion when using a mobile device. This means that users are not devoting all or any of their visual resources to interacting with their device because they are restricted to focusing on their primary task (driving, walking, navigating, etc.); otherwise they risk an accident. As we know, mobile devices have limited screen area, and traditional input and output capabilities are restricted in general to the use of a keyboard, keypad or simple handwriting recognition, depending on the type of mobile device.

Pascoe et al. (2000) report that interface design for field workers using a mobile device (usually a PDA) for data collection tasks is based on two general principles: the Minimal Attention of User Interface (MAUI) and context awareness. The MAUI seeks to minimize the attention required, but not necessarily through the number of interactions required from the user in operating the device. Context awareness enables the mobile device to provide assistance based on knowledge of its environment or means that it has the capacity to sense its environment.

We can assume that environmental officers use a mobile device in the same way as field workers do, as Pascoe et al. (2000) mention that there are four characteristics of user interface design that should be considered in mobile devices for field workers . These are listed below.

Dynamic User Configuration: The field worker's task is to collect data whenever and wherever they are needed. Field workers do not have chairs or desks upon which to set up their computing apparatus, but nevertheless need to record data during observations whether they are standing, crawling or walking. Likewise, environmental officers need to obtain information whenever and wherever they like in whatever conditions (walking, running, driving, etc).

Limited Attention Capacity: Data collection tasks are oriented around observing the subject. The level of attention required is dependent on the nature of the subject. For example, when observing animal behavior, field workers must keep constant vigil on the subject so as to be able to note any changes in state, so they have limited time to interact with the recording mechanism. Similarly, mobile environmental officers also need a device that can minimize the time devoted to interacting with the mobile device in order to obtain the relevant information.

High-Speed Interaction: Using observation of animal behavior as an example, subjects requiring time-dependent observation are highly animated, and field workers must enter high volumes of data very quickly and accurately or it may be lost. Similarly, environmental officers may sometimes need to make high-speed interaction to obtain relevant information.

Context-Dependency: Field workers' activities are intimately associated with their context or the subject's context. For example, in recording an observation of an elephant, its location or the point of observation will be recorded, too. In this way, the data recorded is self-describing of the context from which it was derived. The same could be said of an environmental officer observing a polluted area, which may self-describe the context from which it was derived.

Although the relative importance of these four factors can vary between different field workers and mobile users, almost all factors listed above are needed by them in mobile application. To solve the problems of limited attention capacity and dynamic configuration of the user, much research has been carried out in which different approaches have been highlighted and constructed involving input devices and mechanisms, from simple and low-cost hardware and software to high-end and additional hardware requirements. Starting from the assumption that small devices are used under the same conditions as computing devices, which require an input and output device, so the design of input and output modes is also important to mobile applications to make interaction smoother.

Conclusion

In conclusion, we can say that there is one important question to be answered and taken into consideration when designing applications for mobile devices: how to push and represent an adaptive amount of geo-information by means of a small device. There are also several factors that are constraints to designing the user interface, such as small and lightweight hardware, hands-free operation and no full attention demand. These requirements could represent a guideline for designing the best interaction techniques for mobile devices.

As explained earlier, when users or "field workers" are working outside the office (e.g. environmental officers), they will undertake tasks dynamically, whenever and wherever they like, in whatever condition. They will also have limited attention capacity, depending on the nature of their subjects, and therefore their time for interacting with the device or mechanism will be limited. While on the move, field workers may sometimes need to have high-speed interaction in order to obtain immediately relevant information, so this must be taken into account in the application development. Context is also very important and plays an important role in answering both questions above. In order to interact efficiently with the mobile device, we can divide the interaction technique into two categories: output mechanism and input mechanism. For the output mechanism, both hardware and software development are involved, and interaction techniques that might be used must be effective and safe. For example, using a head-mounted display in order to cater for screen size issues, and for software development, the device must have a sensor that can recognize the context involved, such as a sensor that could recognize the weather and alter the brightness of the display based on weather information. Besides this, the output mechanism must account for user interaction needs, such as an "eyes-free" or "hands-free" approach to give users freedom in their actions. Gesture type or to what extent speech-based interaction is socially acceptable, otherwise known as social context, are also important in choosing an interaction technique. Other than that, physical context (e.g. changes in ambient temperature, noise level, etc.) and task context are also important. There are various techniques (such as wearing headphone-based 3D audio, using a gesture and non-speech audio) and applications (such as the Nomadic Radio application, Cocktail Party) that have been used and studied to represent information to the user. For the input mechanism, there are various techniques and ways to input data such as multi-tap, two-key and linguistic disambiguation. Various devices can be used, such as Twiddler2, BAT Personal Keyboard, Senseboard, Lightglove, KITTY, Finger-mounted keyboard, Chording Glove, Pinch Glove, Thumbcode Glove, etc. and various techniques such as tilt-based interaction, TiltText, Unigesture, GestureWrist, FreeDigiter, WristCam, Peephole, AppLens and LaunchTile.

The mode of interacting and representing appropriate information to the user must involve context-aware technology, so a system (software) or device (hardware) can adapt and provide relevant information in order to suit the needs of the user, of the environment, and of the equipment. In other words, an application must be context-aware and capable of perceiving the user's situation in its many aspects. And adaptation is a goal of context awareness which is able to drive the application without explicit tuning operations by the user. Involvement of context awareness in the Geo-info to-go project is very important in order to support the surveillance activities of environmental officers. By using this approach, the system can push the proper amount of geo-information based on the profile of the user, identity, location and behavior. Thus it could indirectly solve storage limitation problems and provide only related and relevant information based on user needs. This special kind of location-aware, adaptive, context-driven device can supply geo-information to a group of users whose activities are well depicted and understood, bringing this application as a complete system to an environmental application that can aid environmental protection.

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References

Chaari, T., Laforest, F. and Celentano, A. (2004). Design of Context-Aware Application based on Web Services. Technical Report CS-2004-5, Università Ca'Foscari di Venezia.

Pascoe, J., Ryan, N. and Moves, D. (2000). “Using While Moving: HCI Issues in Fieldwork Environment”.

Reichenbacher, T. (2004). Mobile Cartography – Adaptive Visualizations of Geographic Information on Mobile Devices. PhD Thesis, Institut für Photogrammetrie und Kartographie, Germany.

Sun, J. Z. and Sauvola, J. (2003). Towards a Conceptual Model for Context-Aware Adaptive Services, in Parallel and Distributed Computing, Applications and Technologies. PDCAT’2003, Proceedings of the Fourth International Conference on Parallel and Distributed Computing, Applications and Technologies, pp. 90-94.