

TOWARDS USABLE CONTEXT-AWARE MOBILE HANDHELD APPLICATIONS

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Abstract

This paper presents author's PhD research in progress on human-computer interaction with context-aware mobile handheld devices. The HCI related possibilities and problems are charted with several studies concerning different aspects of context-aware applications, including such as users' perceptions of context, user defined rule-based user interfaces, and privacy. The thesis aims to provide design guidelines for context-aware mobile applications.

1. Introduction

During last ten years, mobile handheld devices have become an integrated part of our life. While the information technology development has enabled more complicated functions and services, the role of mobile device as a generic tool in every day life has grown. This brings possibilities as well as difficulties to the user, as (s)he has to manage growing number of features and ever increasing information push. Mobile handheld devices are used in various kinds of situations, which change dynamically, and they employ different preferred features according to the particular situation. As the input and output functionalities are limited because of the small size of the device, the efficient input capability and presentation of the relevant information are emphasized. Mobility and size requirements set special needs for the user interface design and interaction methods.

In short, context-awareness aims to use the information of the usage context for adapting the behaviour of the device according to the situationally appropriate means. It has been proposed as a potential step in future technology development, as it offers possibilities e.g. to smart environments, adaptive user interfaces, and more flexible use of devices. Taking in the account the special characteristics of mobile handheld devices, they form a well-suitable platform for context-aware (CA) application development. Context-awareness itself is relatively novel field, and context-aware mobile handheld devices have previously been investigated very little from the usability point of view.

The ideas of context-aware computing can be tracked down to the days when Mark Weiser published his famous paper 'The Computer for the 21st Century' [15]. Whereas Weiser above all introduces the fundamental concepts of ubiquitous computing by 'vanishing computers into the background', he also proposes context-aware computing: '*... computers will come invisible to common awareness. People will simply use them unconsciously to accomplish everyday tasks*'. Weiser paints a picture of computers knowing their location, being able to information capture and context-based information retrieval, and offering seamless interaction to support user's current

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tasks. In [5], Dey and Abowd define the context as *"any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves"*. This definition is selected as a starting point at this work.

With context-aware mobile devices, location is probably the most commonly used variable in context recognition, and there has been a number of studies and demonstrations concerning location-aware mobile applications such as shopping assistants, guides e.g. in city or campus area, see for instance [2], [3] and [4]. Sensor data can be used e.g. to recognize the usage situation from e.g. illumination, temperature, noise level, and device movements, as described e.g. for mobile phones in [6] and [7] and PDA in [8], where the contextual information is suggested to be used e.g. for ringing tone settings and screen layout adaptation. So far, the usability issues and human-computer interaction (HCI) with context-aware applications has been investigated only little. To name some of the few, Truong et al. introduce an interesting poetry interface approach for home applications [14]. Among mobile context-aware devices, the concerns of lacking user control are risen in [1].

2. Research Questions and Methodology

Currently, having a context-aware system integrated on a device is not a default case, as applications are built and implemented as blocks, which operate without adaptability to different situations. Personalization and configuration is done manually by changing settings. However, context-awareness may provide a powerful tool to enhance the efficiency and usability of mobile applications. The main research questions of the thesis are, *'To what extent can context-awareness increase the usability in mobile handheld applications?'*, and *'How can this be done?'*.

The author's PhD thesis aims to contribute to the following research aspects. First, it seeks to chart the problems related to the HCI issues in context-aware mobile devices. Secondly, it proposes guidelines to help the interaction and user interface design of context-aware mobile devices. This twofold contribution is well justified as the existing research has not yet much on the human-computer-interactions aspects, although charting the problems, possibilities and users' expectations form essential knowledge background for successful application development.

Previous research conducted in the field of context-aware mobile applications does not provide significant amounts of information nor experiences on HCI design but rather separate or narrowly focused cases. Thus, the author had to start with several wide open questions. The problem is approached by conducting several, separate studies, where different aspects of HCI issues with context aware mobile applications were charted. This was done to get a big picture and fundamental ground knowledge of the issues related to the topic. After this, the author steered the PhD research from general towards specific in order to provide wider and more complete guidelines on the issue.

The author's aim was to attain the objectives by first conducting several smaller research studies, and, after this, gathering the cross-study results consistent and emphasized in the studies, and finally, by constructing design guidelines for interactive context-aware mobile systems based on the gained results. The thesis heavily builds on the scientific publications (co-)authored by the thesis's author, published during the post-graduate study and research period. The thesis does not

aim to describe system architectures or context recognition, which are excluded because of their transparency to HCI issues which are in the core focus of this PhD.

The research problem is approached by conducting several studies with different kind of research methodologies, each suitable for corresponding to the nature of the study and questions in focus. Generally, the preliminary studies conducted in the earlier phase of PhD research are more exploratory and employed a suitable user study methods, for instance interviews and wizard-of-Oz testing, whereas later studies were conducted with methods such as paperprototyping with designed UI, architectural considerations, and handheld prototypes. Along these lines, the research aimed first to chart general trends, and then focus on found hot spots and barriers on the problematic of usable context aware UI's. Thus, the research problem was confined more during the process.

Combining different user interface design and testing methods was done for two reasons. Firstly, as the research was composed of a relatively large number of smaller studies, an optimal testing method was to be selected for each. Selection of just one method would have limited the potential information flow, as the approach was different altering from exploratory studies to verifying and testing ready-made applications. By including several different methods enabled richer information gain. Secondly, different methods were selected to ensure and maximize the validity of the findings.

3. PhD Research

Conducted research concentrates around three themes: location-awareness, user-defined settings for context-aware applications, and privacy with context-aware applications. These topics were investigated within several separated studies, which are introduced in sections 3.1 – 3.3. Current state of the study, section 3.4 contains drawing the synthesis from the individual studies, and developing them to design guidelines.

3.1 Location-Awareness

In [9], perceptions on location sensitive push messaging were gathered, and usability issues of selected features, such as message categorization and visualization of uncertainties in location determination, were charted. When asked what kind of location dependant information the subject would be interested in, the selections varied greatly from public transport timetables to ATM's and drinking fountains, resulting 19 different categories from eight participants. In [11], multimedia messages (MMS) applying location-awareness were demonstrated. The used applications were presence, reminder and private and public notifications. When charting people's expectations of location-aware push messaging, the strongest finding was the fear of 'spamming'. Personalization and filtering of location sensitive push messaging were highly valued features. The possibility of just anybody messaging to the subject's phone was generally considered as intruding, but the setting of location-aware messages to selected groups, e.g. friends, was perceived useful. Also, defining of personal, location-sensitive reminders and notes was considered valuable. These findings were consistent in both studies.

3.2 User-Defined Settings

Users' ideas of context sensitive settings was studied in [13]. For the study, a user interface where a user can define the environment conditions for triggering context sensitive actions was built, and

users were asked to perform UI settings according to predefined conditions. Several different settings were available for each attribute, which the user could combine with Boolean functions *and*, *or* and *not*. User was asked to perform settings in order that *if* the setting condition was fulfilled *then* an action was activated – e.g. *if* I enter to my office tomorrow in the afternoon, *then* send the SMS to Laura. The results suggest that users in general are able to select conditions for context-based behaviour of applications, but the selected use strategies vary significantly in between individual users. All eleven participating subjects almost unanimously selected different conditions for tasks given in scenarios. Also, the amount of erroneous settings was considerable. Subjects had difficulties especially with performing functional conditions when using Boolean operators. The results also showed that people can have very different idea of context, and they follow their personal understanding and style in defining contextual settings.

This study was followed by a further project, with redesigned user rules and application interface. In [12], end-user programming tool was designed and implemented on Nokia Series 60 mobile phone. The rule building was simplified, and user-defined use of Boolean operators was removed. The folder hierarchy for context attributes was automatically created by utilizing context ontology. User tests showed that users performed well with the application. One interesting result found was that although the application allowed the use of several triggers, users favored building simple rules with only one condition trigger.

3.3 Information Sharing and Privacy

In [10], users' perceptions of context-dependent information sharing were investigated. A context sensitive mobile application, where the user could define different privacy profiles for information sharing was implemented and evaluated. Results also indicate that people have strong willingness to have control over the data they share as well as to define several groups of trusted people, with who they could share information more freely. Users also showed tendency to define privacy profiles with overlapping attributes, for instance by including same people to several profiles.

3.4 Cross Study Results for Developing Design Guidelines

Currently, the author is working on constructing the synthesis from the individual studies, which are to be formulated to design guidelines for developing context-aware mobile applications. The cross study results consistently highlight some aspects, which should be taken into account in context-aware application design. These include the following.

As context-recognition is never 100% sure, a special care must be to the conflict management in inferring logic. User's ability to check system status and have control over the decision-making should be ensured. Easy accessibility and configurability are crucial factors, as people tend not to have patience to go through long settings menus. Despite of this, users should be able to do some form of information filtering and personalization. Spamming forms a potential usability and privacy risk if information sharing and push type notifications are enabled. In addition, users privacy should be carefully considered especially with information sharing and presence type applications, which also relate to the social acceptability of the applications.

The future work, which is carried out during the spring 2005, includes the formulated guidelines to be employed in a design venture, which is carried out as a university project. Here, the interaction design of a context-aware mobile application is implemented so that the first design phase contains

only conventional design guidelines. After this, the guidelines are enhanced with design guidelines for context-aware mobile applications provided by the author, and design iteration is done. The proposed guidelines are assessed by verifying the designs before and after the evaluation, and by interviewing the application designers.

4. Conclusions

In this paper, the author has presented her proposal and research in progress for her PhD thesis. The thesis has a twofold objective. First, it seeks to chart the problems related to the HCI issues in context-aware mobile handheld devices by conducting several exploratory studies. Secondly, it draws together cross-study results, and based on them, proposes guidelines to help the interaction and user interface design of context-aware mobile devices. The research includes several projects concerning location-awareness, user defined settings, and privacy and information sharing. Currently, the author works on constructing the design guidelines based on the cross-study results. This, together with the verification phase, is done during the spring 2005.

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