Indexical Interaction Design for Context-Aware Mobile Computer Systems

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Indexical Interaction Design for Context-Aware Mobile Computer Systems

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ABSTRACT
This position paper outlines a current research project focusing on the challenges of interaction design for context-aware mobile computer systems. This challenge is approached from a novel perspective on context-awareness; by exploiting knowledge about the user's context to create *indexical user interfaces* that carry a major part of their meaning implicitly through the settings in which they are used, thus reducing the need for explicit information representation cluttering the limited screen real estate of mobile devices. The research project aims at creating a theoretical foundation for future research into interaction design with context-aware mobile computer systems and to develop the concept of indexicality as an interaction design principle for such systems. Achieving this, we are conducting a theoretical as well as a technical stream of research involving field studies into the context of mobile computer system use and experimental design, implementation and evaluation of prototype systems.

Categories and Subject Descriptors
H5.2. [**Information interfaces and presentation (e.g., HCI)**]: User Interfaces - *User-centered design, Graphical user interfaces, Screen design*.

General Terms
Design, Human Factors.

Keywords
Context-awareness, Indexicality, Mobile Systems.

1. INTRODUCTION
The last decade has seen an increased development and use of mobile computer technologies within a wide range of use domains. This includes general applications and services such as SMS, MMS, mobile e-mail and chat, wap- and miniature web-browsers; business applications for time managing and mobile access to cooperate information; leisure applications such as mobile game consoles, MP3 players and GPS route planning; and highly specialized applications for supporting safety-critical and information-intense mobile work activities within, for example, healthcare.

Currently, these applications typically run on conventional mobile computer devices such as personal digital assistants and mobile phones employing interaction styles similar to their desktop counterparts (for example WIMP and Direct Manipulation). While these interaction styles do make it possible for a mobile user to operate a handheld computer, the human-computer interaction enforced by combining traditional interaction styles with the small screen sizes and limited means of input of mobile devices in a highly dynamic use context is far from optimal.

The prevalent use of traditional interaction styles for mobile computers means that the usability of mobile information and communication systems suffers from compact interfaces cluttered with information, and interaction requiring the user's full visual and cognitive attention. This limits mobile use of such systems (e.g. walking in the street or treating a patient at a hospital) where a lasting change of focus away from activities in the real world may not be possible. If mobile devices are to have higher usability for mobile users, interfaces must remain simple and the required interaction minimal.

Advantages in technology have made it possible for mobile computers to access information about the user's context such as their physical environment, location, social setting, and current activity [7] [8] [10] [12]. Recent research in human-computer interaction for mobile devices has demonstrated that the usability of mobile computer systems may benefit from utilizing this information to tailor the information and functionality presented to the user in a given situation [3] [4] [5] [9] [13].

The potential benefits are several. By making mobile computer systems aware of their user's contextual setting, designers can use this information to present only information and functionality relevant in specific situations [3] [5]. This way, the user interface can be simplified and the demand for user interaction can be reduced. Tailoring the interface to its context may also facilitate partial automation of repetitive and trivial tasks [10]. Also, making the system react to contextual changes may be used to increase security of data and users [19]. An example of combining some of these potentials is a context-aware mobile patient record system. In such a system, interface and interaction complexity can be reduced significantly by tailoring the interface to the nurse's

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location (wards, hallways, operation rooms, etc.), current work activity, patients within proximity etc., and making the system automatically monitor these factors and react to changes [14].

However, the promise of context-awareness for mobile information systems has not yet been fully realized in practice. So far, the impact on human-computer interaction design for commercial products has been insignificant. The reasons for this are many.

Firstly, the concept of 'context' is still vaguely defined and understood on a theoretical level in relation to mobile computer use [1] [6]. For example, it is unclear how different aspects of the user's context influence their perception and use of different mobile information and communication systems. Also, it is still unclear exactly how to utilize knowledge about context in mobile computer interface design; how to decide what information and functionality to present to the user, what to leave out, and how to make use of information already implicitly present in the user's surroundings [13]. Finally, it is unclear what the limitations of context-awareness are in relation to mobile human-computer interaction and how users will react to and use such systems. For example, it has been argued that making mobile systems react automatically to contextual changes may result in unfortunate loss of user control [3] and that the user interfaces for such systems must be designed carefully to prevent this problem.

A promising and novel approach to interface design for context-aware mobile systems is the concept of indexicality derived from the semiotics. Semiotics concerns the meaning and use of signs and symbols. A semiotic approach to the design of context-aware mobile computer interfaces can contribute to a theoretical understanding of information representation and the design of context-aware user interfaces. From a semiotic perspective, information is viewed as representations of something else (their object). Faced with an interpreter, these representations cause a reaction or interpretation (figure 1). The semiotics operates with three types of representations: symbolic (conventional), iconic (similarity) and indexical (material/causal). Symbols and icons are ways of representing information independent of context like e.g. text and graphical illustrations. Indexes, on the other hand, are ways of representing information with a strong relation to, for example, their spatial and/or temporal context exploiting information present in the interpreter's surroundings. Indexical representations are e.g. used on signposts and information boards. Thus, for example, locating information in time and space, symbolic and iconic representations can be converted into temporal and spatial indexical representations [2]. As shown in [16] increasing the level indexicality results in a significant reduction of required symbolic and iconic representations.

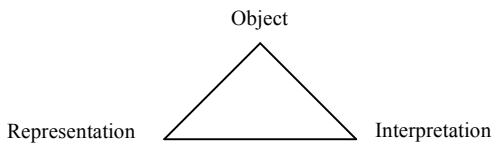

Figure 1. Semiotics: the relation between object, representation and interpretation

The idea of applying indexicality to interface design for context-aware mobile computers is that if information and functionality on a mobile computer can be indexed to the user's situation, then information already provided by the context becomes implicit and does not need to be displayed. Hence, the user's environment becomes part of the interface. On the basis of this, the limited screen real estate of mobile devices can be optimized to contain only the most vital content and the required user interaction with mobile devices can be reduced. As an example of this, an indexical mobile information service for patrons entering a cinema complex could be made temporally and spatially indexical by taking into account the time, location and social context of the user, providing only information about the upcoming movies playing within a limited frame of time (temporal indexicality) in that specific cinema (spatial indexicality) [16]. The concept of indexicality has been explored preliminarily in [11] [14] [15] and has proven to be a promising, but yet challenging, approach to context-aware mobile computer interface design. Relying strongly on the user's knowledge about, for instance, where and when they are situated, successful design of indexical interfaces for context-aware mobile computers, however, necessitates a better theoretical understanding of what constitutes the user's context, and explorations of how indexing user interfaces to context can be done in practice.

2. THREE PROTOTYPES

So far, our research has resulted in a series of indexical interface designs for mobile context-aware prototype systems. Three of these are briefly described below.

2.1 TramMate

TramMate (figure 2) is a context-aware mobile information service providing users with a route-planning tool for the tram based public transport system of Melbourne, Australia. It was specifically targeted at business employees who, during a typical workday, have to attend appointments at different physical locations. The fundamental design philosophy behind the interface design of TramMate was to minimize information displayed to the user by indexing to the contextual factors, which the system was aware of, such as location, objects (trams), upcoming appointments etc. TramMate does this by keeping track of contextual factors such as the user's physical location, upcoming appointments and real time travel information. The design is integrated with an electronic calendar and alerts the users when they should commence their journey [11].

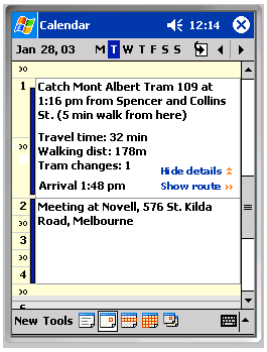

Figure 2. TramMate: route-planning information for public transport indexed to location and scheduled activities

2.2 MobileWARD

MobileWARD (figure 3) is a mobile context-aware Electronic Patient Records (EPR) terminal prototype, which automatically keeps track of contextual factors such as the physical location of

patients and staff, upcoming appointments etc. In this prototype design, the concept of indexicality was used to minimize and streamline the information presented to the nurses and doctors on the basis of the system's knowledge about their context. For example, the design takes into consideration that when presenting information about a patient, that patient will be physically present in the room with the nurse or doctor, thus leaving out implicit information and taking them directly to information about the treatment of that patient rather than requiring them to navigate a complex database system (which is typically the case with traditional EPR systems) [15].

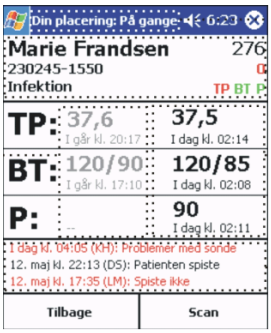

Figure 3. MobileWARD: Indexing patient information to patients in proximity, location and upcoming work activities

2.3 Just-for-Us

Our most recent indexical prototype system is a context-aware mobile web site, Just-for-Us, facilitating sociality in the city of Melbourne, Australia by providing the user with a simplified digital layer of information about people, places and activities within proximity adapted to users' physical and social context and their history of social interactions in the city (figure 4). In this prototype, indexicality was, amongst others, used to 1) create strong links between the information in the system and the real world surrounding the user, 2) reducing the information needed when presenting specific content (such as recommendations) to a group of users, and 3) generating easy-to-use way-finding descriptions referring to the group of user's familiar places, and thus exploiting their existing knowledge about a space [14] [17].

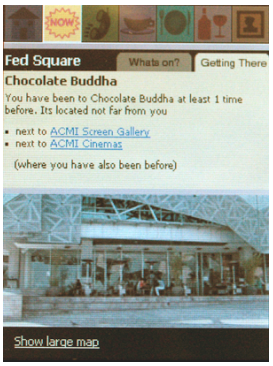

Figure 4. Just-for-Us: Indexical way-finding instructions based on physical context and history of visits

3. THREE EVALUATIONS

Because the use context plays such a fundamental role in the interpretation of an indexical interface, evaluating indexical mobile information systems is a particular challenge [18]. For example, it can be questioned which settings, lab or field, would be most appropriate to conduct evaluation in. Enquiring into some of the challenges of evaluating indexical context-aware mobile computer systems, all three prototypes described above were evaluated through comparative usability studies in both lab and field settings. As a part of this, we have developed a mobile audio/video recording studio, which we can take with us into the field. Figure 5 shows one of the 20 evaluation sessions of the Just-for-Us prototype system conducted in Melbourne, Australia during April and May 2005.

Figure 5. Field evaluation of the indexical context-aware mobile web site Just-for-Us

The fundamental idea behind indexing information and functionality on a mobile device to the user's context is to facilitate a reduction of the information necessary to be presented explicitly to the user and relying on implicitly present information instead. In relation to the use of the three context-aware prototypes exploring this principle described above, our evaluations have shown us that people are generally highly capable of making sense of sometimes very reduced and fragmented information – depending on the contextual factors adapted to and provided that the right clues for the interpretation of information were given. For example, we found that presenting information indexing to the user's location is typically understood right away without explanation needed. Also, providing minimalistic way finding descriptions that index to the user's familiar places made immediate sense to most users (for example, "next to the ACMI cinemas" or "corner of Collins and Swanston St.") and facilitated finding their own path to a destination. However, indexing information to the user's social context, for example, who he or she is with at the time (patients or colleagues at the hospital, friends out on the town, etc.) was often initially found to be unclear when not indicating that this was what the system was doing. As an example, factoring the favourite places to socialise of friends they are currently with into recommendations in the Just-for Us system was seen as a helpful aid to activity planning but was not immediately understood by some users. Similarly, most users found indexing information to their history of interactions to be very useful (for example, ranking information about places around them based on their past visits or adapting to apparent preferences for using particular tram lines), but many of them expressed a desire for being able to control such ranking mechanisms and requested to have full control over information captured and stored by the system about their physical whereabouts and who are with, when and where.

4. CONCLUSIONS

This position paper has outlined an ongoing research activity into the challenges of interaction design for context-aware mobile

computer systems. We have proposed the concept of indexicality as an interesting new approach to interaction design for this emerging class of mobile systems, and have outlined three examples of context-aware prototype systems where this concept has been deployed in practice and evaluated through user studies. At the workshop, we would like to present more of the empirical and/or theoretical background behind the development of the concept of indexicality for interaction design. Also, we would like to go into details with one or more of the presented prototype designs. Finally, we would like to present more findings from the latest field evaluation.

5. ACKNOWLEDGMENTS

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