Context-awareness in Mobile Tourist Information Systems: Challenges for User Interaction

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ABSTRACT

Context in mobile tourist information systems is typically captured as the current location of the user. Few systems consider the user's interests or wider context of the sights. This paper explores ideas of how to model, observe, evaluate, and exploit a richer notion of context in this application area. We discuss the influence of such a richer context model on the user interaction for both the capturing of context and the context-aware user/device interactions.

Categories and Subject Descriptors

H.5 [**Information Representation (HCI)**]: Miscellaneous; J.9 [**Computer Applications**]: Mobile Applications—*Location-dependent and sensitive*; H.3.4 [**Information Retrieval**]: Systems—*User profiles and alert services*

General Terms

Design, Human Factors, Context

1. INTRODUCTION

Advanced tourist information systems provide targeted and up-to-the-minute data that is semantically-rich to mobile users, based on the user's preferences and travel history [5]. Some systems also recommend sights that match the user's context. Our system for mobile tourist information, TIP, considers the personal background of a traveller both for selecting the information that is delivered to the user and for recommending routes and sights. User context also includes their interest, location, means of travel, and the current time. A user's interests are captured in a personal profile, their travel history, and by giving feedback about items in their travel history. The systems also takes selected aspects of the semantic context of sights into account (e.g., their location, their type, and similarity to other sights).

In this position paper, we identify the challenges for context handling in mobile tourist information systems. We discuss how to address these challenges in user interaction and interface design. In Sect. 2, we introduce the basic concepts of our TIP system, which is then used in subsequent sections as an illustrating example. In Sect. 3, we identify the challenges for context modelling, observation, evaluation, and exploitation in an extended TIP environment. In Sect. 4, we discuss the particular issues of user modelling; Sect. 5 focusses on user interaction. Sect. 6 briefly compares related research. Finally, we conclude the paper in Sect. 7 with plans for future work.

2. TIP BASICS

TIP [5] is a mobile system that delivers information about sights (information objects) based on the user's context: their location, two personal profiles describing interest in (semantic) sight groups and topics, and the user's travel history. The system also considers the sights' context, such as their location and memberships in semantic groups. Sights that are in a semantic group share certain features (e.g. medieval churches). For recommendations, we assume that a user who has seen several sights in a group is interested in seeing more. Recommendations are also given based on user feedback and profiles [4]. TIP also supports navigation by maps. The current location and the location of sights is dynamically indicated on the map.

The TIP system has an event-based infrastructure combined with a location-based service. The heart of the system is the filter engine cooperating with the location engine. The filter engine selects the appropriate information from the different source databases depending on user and sight context. Thus, the systems interaction logic is defined in context-aware profiles for the event-based filter engine. Figs. 1 and 3 show the TIP system in use.

The system is implemented as a client-server architecture, supporting desktop clients as well as mobile clients on a hand-held device with appropriate interfaces. We are currently extending the system to support groups of user devices interacting as P2P nodes.

3. TOURISM CONTEXT CHALLENGES

We consider three facets of context: (1) the concepts of context pertinent to a mobile tourist application; (2) the issues one faces when managing context data; and (3) the usage of the context data. We will discuss how each of these challenges affects the interface and interaction design.

(a) current location (b) recommendations

Figure 1: TIP in Use: Context-dependent information delivery; interface with (a) current location on map and (b) recommendations showing only sights of interest to this user

3.1 Context Concepts

For a mobile information system, several aspects of context can be considered (see Fig. 2), such as the characteristics of the particular mobile *device* (storage and screen size) and *network* (bandwidth and peers), context of the *application* (requirements in storage, download and display capability), context of the *user* of the system (e.g., time, location, interests), context of *information objects* (e.g., location). The handling of the concept data depends on the intended usage: information about the mobile device could be used to adapt the networking mode (to gain efficiency in the system communication) or to adapt the information display (to gain effectiveness in the user communication); see Sect. 3.3.

We believe, that a system's concept of context needs to be *open and extensible* in order to address various application environments. In general, the concept of context is only pertinent if the system supports context-adaptation or context-awareness. That is, change must be an inherent and explicit concept in the system. Also, the changes should not be directly predictable; otherwise a simple parameterisation would be more appropriate.

3.2 Context Management

For the management of context we distinguish four tasks: modelling, observation, storage and access. We focus on the user-related challenges for each of the aspects. The usage of context is addressed in the next section.

Model: A mobile information system needs an open hierarchical approach to context modelling, that is, context should be explicitly modelled on several levels to support further change. Here we consider only the application aspect in detail (see Fig 2). Using a top-down approach, the highest level should be that of the *application context*: context-based information delivery could be used in general tourism, museum guides or in a eLearning context. Basic interaction patterns remain, but the specific interactions and services may change. For example, in a tourism environment the location may be determined in relation to terrestrial coordinates whereas in a museum the location may be determined by proximity to objects.
On the next level, users interact with objects (e.g, tourists are interested in sights). For each of the players (user and object) a context model should be supported. For tourism applications, *user context* can be static or fluent. *Static context* is relatively stable, e.g., user interests, personal background. It can have different versions that may be captured in user roles (user as private traveller or in business context). *Fluent context* typically changes continually, e.g., time, location, and direction of a particular user. We discuss the user modelling in more detail in Sect. 4.
The counterpart of the user context in a tourism application is the *sight context*. Sight context can be distinguished in being *general* and relatively fixed (e.g. location, opening hours) or *current* and pertinent to this user. Current sight context is derived from the interaction of user context (time and weather) and sight context, e.g., sight popularity combined with the user's own interests.

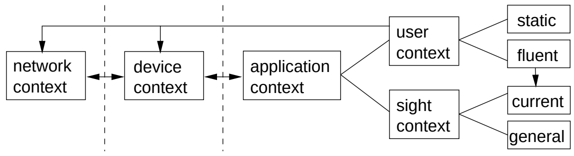

Figure 2: Selected context aspects. Arrows indicate influences in the evaluation

Observe: The application context is assumed to be relatively static. New services might be on offer depending on the location of the user (cf mobile telephony). For these, an infrastructure must be provided to dynamically integrate or release services. Most general object contexts can be pre-captured. The observation of the user context and the evaluation of the current context of the objects is more demanding.

User context data can be automatically observed (triggered by time intervals or change larger than a given threshold) or manually entered by the user. The way the context is captured influences how the data can be used (due to different semantics of the data). Automatic context capturing may lead to efficiency problems (continuous observation, high load for mobile system) and failing user acceptance (privacy issues); user-dependent context entry may lead to failing user acceptance and HCI issues (discussed in Sect. 4).

Store: Data about the user context may have to be available on the mobile device as well as on the server. The data needs to be stored and distributed in an efficient way. For several applications, privacy and security issues have to be addressed: only selected peers (sometimes not even the server) should have access to the user's private data. For user acceptance, the user needs to trust the service not to distribute the data. Therefore, the system's actions need to be transparent.

Access: For access to (context) data, the same issues arise as for storage: efficiency and privacy. Context-awareness can be used to reduce the amount of data to be accessed and distributed by preselecting the pertinent data. Context-aware data access faces the sparse-data problem when new users or objects enter the system. Few data might be known initially, making data selection based on user-context (personal preferences) a difficult task. As a solution, information about similar users or sights might be used; here, trust and privacy issues need to addressed.

3.3 Context Usage

Usage and benefit of context information depends on the quality that the system designer aims for. We identify effectiveness and efficiency as non-distinct criteria.

Effectiveness Aiming for effectiveness in the system design of a mobile information system means that the pertinent (i.e, right) information is delivered to the user in a way that they are satisfied with the service. Affected aspects are the context-dependent selection of the information and its presentation to the user, i.e., the design of the interface and the information representation on the small-screen, mobile device (HCI issues). Questions to answer include: *How do different contexts influence the data selection?* and *How are different data contexts represented to the user?*

Efficiency The system's interaction with the user should not be impaired by data storage and exchange. This affects the implementation of the context-dependent selection of the communication model, communication partners, and local storage on the mobile system as well as context-aware pre-caching strategies and display options. Other issues include the data quality (e.g., size of maps and bandwidth for videos) and network and device restrictions.

Both criteria are interdependent so that a user might be given the choice of greater latency for better quality of information provided. These user preferences also provide further context for the system design.

4. MODELLING THE USER

A key challenge in delivering well-targeted information to the user is to create a high-fidelity profile of the user's interests and preference. Were users consistent individuals with slow rates of change, good user modelling would already be challenging. However, users switch roles and situation rapidly – changing mode of transport, role and interest. For example, a tourist may meet up with a friend in a town, and suddenly have access to a car and an additional set of interests and constraints. Conversely, another user may be primarily visiting a town for work, but have a Friday evening free for leisure – normally they would seek out a nightclub, but due to their work commitment the next day, they pursue a less exhausting alternative. Thus, one of the great questions is how to capture changes in the users role, such as business context or personal context.

Could such changes can be represented by selecting a different, but essentially static, roles? Other options might be capturing of situations based on location (e.g., nightclub) or behaviour patterns (work context from 9am – 5pm).

(a) current location, with darker colour scheme

(b) distant location, with lighter colour scheme

Figure 3: TIP information delivery based on user context – location, interests, and travel history: (a) Delivering information about user's current location, (b) Browsing for information about a distant location. Interface design based on the interaction context.

Another challenge is the interaction between user preferences and other contexts (indicated by arrows in Fig. 2). The user's preferences in the display mode depend on the available options of the device. They may additionally depend on the user's static context (e.g., shortsightedness) as well as fluent context (e.g., high photosensitivity at night time), influencing context for information display and delivery mode for the application.

A third user related issue is the trust model. Trust may relate to the current network context (available peers in close proximity) and the user (data sharing only with trusted peers). Trust in peers, applications, and devices will influence the available information and has to be addressed in the user interface (e.g, identifying peers by name).

5. INTERACTION

Where the system's appearance and behaviour is so affected by context as we anticipate, interaction issues rapidly emerge.

First, the key HCI issues of scrutability and interpretability become immediately problematic. Facilitating the user's inspection of why they are being shown the current information should improve user satisfaction and their mental model of the system's operation. However, this adds interactional complexity. Furthermore, given the computational complexity of most recommender systems, for example, providing reliable yet immediately comprehensible insight into why the system behaves as it does is deeply challenging.

Secondly, consistency is considered to be a highly desirable characteristic for any interactive system. However, where a system responds to fluid changes in context, it's appearance and/or content will frequently be changing. Close study and evaluation of this problem will be required for TIP and similar systems over the coming years.

The consequences of these requirements are not well known even in other context-aware systems. In mobile context-aware systems, the limitations of interaction and display exacerbate these existing challenges. A comparison may be drawn to interactive search: users of search engines consistently prove to have a poor understanding of their operation and sub-optimal strategies, leading to poor performance. In small-screen, mobile search contexts, performance drops further and strategies become even more rudimentary. How, and to what degree, similar problems emerge in context-aware mobile systems remains to be discovered.

Further complications arise regarding some commonplace navigation metaphors as they interact with a mobile user and unreliable network and position technology. This can result in a disjunction between a user's physical and digital context – e.g. if positioning fails, the system's sense of 'where I am' will not be in accord with the user. More complexly, if the user accesses the 'home' page of TIP, with information on the current location, and they then browse to a different document and whilst reading that document they move position, the home page content will display information about their current context, not the previous 'home' context.

One traditional means of viewing what the user has already seen in a document browser is to use a 'back' button or similar, that retraces the stack of their browsing. However, the system must not only retrace the item viewed, but the context present at the point when it was viewed to give a consistent presentation. Studies of such history-based navigation have also revealed fundamental usability problems in their treatment of sequence with static documents [3]. We hypothesise that these known problems will be worse in context-aware documents.

At present, we have designed TIP in line with the existing knowledge of interaction design for browsing and searching, using the well-proven outline-style interaction [1, 6], as seen in Fig. 3. We are now preparing user studies to explore the complex issues outlined in this section.

6. RELATED WORK

Several mobile tourist information systems have been designed. For most of them the only context captured is the users and the sights locations: TouristGuide [10] is a location based tourist guide application for the visitors to the Adelaide city center. The system concentrates on sight contexts; no user preferences are used and no recommendations are provided. Some systems capture client interest (in a profile) as well as the location for information delivery: Guide [2] provides tourist information according to a users current location and sight information e.g. sight opening and closing time, and users visit histories. Crumpet [9] is a mobile personalized and location-aware services for tourists. A user provides their demographic information; the system updates the user profile during their interaction.

Few systems explore richer context for user interaction: AccesSights [8] is a mobile tourist guide for blind and visually impaired people. Here, the user's context influences the modality (medium) used to display information to the user. MAS [7] informs patients with chronic diseases about medication and health related data. The display of the data depends on the immediate user context (such as the time of the day) and the user context (such as the disease, e.g., vision impairment). Though each of these systems does provide additional or different contextual models when compared to location-only systems, user models and information models are often relatively static (e.g. changes are explicitly performed by the user). Such limited models provide highly discrete but ultimately coarse-grained models of user and information that are unlikely to satisfy user needs when faced by the need to select specific, highly relevant information from large, fluid, information bases to meet dynamic user needs. However, each highlights further dimensions of context – e.g. in a noisy environment, all users are functionally 'deaf'.

7. CONCLUSION

In this paper we introduced TIP, a mobile tourist information system that presents information to the user that is sensitive to the user's context, interest and the related context of neighbouring sights of interest. TIP provides map-based and browser-based information navigation, and uses contextual hierarchy to support outliner-style browsing that is efficient on small screen, mobile displays. TIP's advanced features raise issues of trust and privacy in addition to challenging the interpretation of well-established HCI principles in the case of context-aware systems. We are now commencing user studies of the use of TIP to explore and, eventually, resolve these issues, furthering our understanding of context-aware systems such as TIP and fundamental issues in human-computer interaction.

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