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Editorial

# Understanding interaction with mobile devices

**Abstract**

This editorial paper introduces an emerging and important area for human–computer interaction research, which concerns interaction with mobile devices. The design of interactive mobile applications should differ from that of traditional desktop applications. To this aim, the paper discusses some concepts and models that help to understand the new challenges as well as recently introduced techniques that can be useful for exploiting the characteristics of these devices. Lastly, tool support for the design of nomadic applications is considered, taking into account the potential contexts of use, with particular attention to the platform features.


*Keywords:* Human–computer interaction with mobile devices; Multi-platform applications; Context of use

## 1. Introduction

A number of interesting challenges have been raised by emerging technological trends, such as the ongoing drive to create intelligent environments and ubiquitous computing, whereby systems adapt themselves to satisfy end users preferences in a wide variety of contexts. Complete solution of these issues will require a long time. This special issue provides a useful contribution to resolving some relevant issues related to human–computer interaction with mobile devices. It contains extended versions of a set of papers selected from the Mobile HCI 2002 symposium that was held in Pisa in September 2002. Previously held as a workshop, often in conjunction with other events, in 2002 Mobile HCI was enlarged to a true symposium. I felt there was a need for this change because of the ever-increasing interest prompted by the issues involved in interactive mobile systems and the lack of specific events focusing on such aspects. Although there are events addressing the broad area of ubiquitous computing, they tend to concentrate on other topics. For example, a paper on criteria for the design of interactive mobile phone applications would be considered inappropriate for such events, whereas it would certainly be relevant for Mobile HCI.

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The response to the symposium was positive in terms of submissions and participation. The contributions, especially the long papers, were selected carefully by the International Programme Committee. The result was an interesting and stimulating programme that addressed such important issues as location awareness, design criteria for PDAs, context-dependent systems, innovative case studies, usability evaluation in small devices, and novel interfaces for mobile devices. The interest shown in the symposium was truly worldwide: we had authors from 16 countries in three continents. There was a good balance of contributions from academia and industry.

## 2. The issues

More generally, we can note that recent years have seen the introduction of many types of computers and devices (e.g. cellphones, PDA's, smart watches, etc.), and the availability of such a wide range of devices has become a fundamental challenge for designers of interactive software systems. Users wish to be able to seamlessly access information and services regardless of the device they are using, even when the system or the environment changes dynamically. To this end, computer-based applications need to run on a wide spectrum of devices. These challenges are addressed in research projects such as the CAMELEON IST Project (http://giove.cnuce.cnr.it/cameleon.html), which I coordinate. The project's main point is to develop methods and tools able to support the design and development of highly usable context-sensitive interactive software systems with the support of models that allow designers to better manage the increasing complexity of design. The resulting applications should behave like chameleons! They should be able to change their forms depending upon the types of devices utilised by users to perform their tasks and the surrounding environment.

After the symposium, a group of long papers were selected for this special issue. I think they are a good collection of papers addressing an interesting set of issues (notation for describing interaction with mobile devices, readability of text on small screens, adaptive interfaces accounting for various sources of information at run-time, infrastructures for location awareness that can cope with various technologies, and interfaces for searching information through various platforms).

The paper *Towards an Improved Readability On Mobile Devices: Evaluating Adaptive Rapid Serial Visual Presentation* by Gustav Öquist and Mikael Goldstein discusses two techniques for Adaptive Rapid Serial Visual Presentation (RSVP) and reports on their usability evaluation through a study that involved 16 users. In one case, the exposure time is adapted to the content of the text chunks. In the other, the authors added adaptive features: the exposure time is modified according to the content, the word frequencies and the position of the chunk in the sentence. The main contribution is the evaluation study proving that the use of adaptive RSVP can decrease the task load. The authors describe the algorithms they have developed to improve text readability on small screens.

In the paper *Adapting Applications In Mobile Terminals Using Fuzzy Context Information* by Jani Mantyjarvi and Tapio Seppanen, the theme is an approach to support context-dependent user interfaces for mobile terminals based on the use of fuzzy logic.

They use fuzzy logic to support adaptive user interfaces taking into account various sources of information at run-time.

A different topic is addressed in the paper *ASUR++: Supporting the Design of Mobile* by Emmanuel Dubois, Philip Gray, Laurence Nigay. The paper describes ASUR++, a notation for modelling Mobile Mixed Systems (MMS), which are systems involving both physical and digital elements. With ASUR++ each system is specified by means of a number of components and a set of relationships existing amongst them. The authors claim that the major benefit of using this notation is to help analysts in reasoning about different design solutions when MMS-related issues are addressed. Thus, the main contribution of the paper is providing a conceptual tool for expressing the main characteristics of a MMS in a concise and easy-to-understand manner. The paper also provides an example of application of the notation for a specific case study, including a discussion of possible design choices.

In *Personal Location Agent For Communicating Entities* (PLACE), Justin Lin, Robert Laddaga, and Hirohisa Naito describe PLACE, an infrastructure able to empower a number of communicating entities to understand a common universe of user locations expressed using a common language and exploiting a number of (multi)sensor data fusion techniques. Thus, the final result is a general design of a location system aiming to capitalize on multiple location technologies for the purpose of selectively sharing location information. Additionally, the problem of the controlling access to critical information such as user location is also addressed in PLACE. The main contribution of the paper is the high level of flexibility the approach aims to provide, in spite of the number of issues it has to cope with (e.g. different technologies for user detection, different languages of location devices and services, privacy concerns related to location sharing information, etc.).

The authors of *Sorting Out Searching On Small Screen Devices*, Matt Jones, George Buchanan and Harold Thimbleby, start with the results of an experimental evaluation concerning the problem that affects users' web search interfaces in three different platforms, and propose some guidelines to improve these interfaces and some ideas for better presentation of search results in PDAs. The guidelines also are a good starting point for discussion on this argument.

## 3. The potential solutions

More generally, with the increasing availability of wireless communication technology (such as Infrareds, Bluetooth, Wireless LANs), many new applications are being made possible. However, it is necessary to be aware of the limitations of such technologies in order to better exploit them. For example, the discovery time required to create a Bluetooth connection can be a strong limitation to detect a mobile user. Wireless networks can be useful for some projects, an example has been given by the GUIDE project at Lancaster (Cheverst et al., 2000) but are less useful to identify the precise position of a user. An application of infrareds to determine user position at the room level has been developed in the Marble Museum (Ciavarella and Paternò, 2003) where the multi-modal PDA interface has been designed in such a way as to capture the attention of users while moving from one

room to another and help them to understand where they are, what objects are nearby and provide information regarding them.

Even tools to develop interactive applications change their features if context-dependent applications are targeted. In the context toolkit developed by Salber et al. (1999), the issues associated with more semantic conceptualisations of the interaction techniques (Paternò and Leonardi, 1994) is extended in order to capture and abstract data sensed by the environment (such as people IDs, voice, level of activity, etc.). This special issue contains a paper proposing another direction for extending semantic-based approaches in order to capture location-dependent aspects.

To analyse what changes have come about in context-dependent interactive systems, we can consider the interactor model (see Fig. 1) (Paternò, 1999).

Generally speaking, the possible communication of an interactor can be classified into eight types of communication channels and graphically represented as in Fig. 1, where by input and output information we mean, respectively, information from the user side towards the application side and vice versa:

- *input_receive*, indicating *what* input can be received from the user side;
- *input_trigger*, indicating *when* the result of the input processing of the interactor is delivered to the external side;
- *input_send*, indicating *what* input information is delivered;
- *output_receive*, indicating *what* output data it can receive;
- *output_trigger*, indicating *when* output information has to be delivered by the interactor;
- *output_send*, indicating *what* output information is delivered by the interactor;
- *enabling*, indicating *when* the interactor becomes reactive;
- *disabling*, indicating *when* the interactor becomes inactive.

These communication channels support two main types of information flow: the input, from the user towards the functional core, the output, from the functional core towards the user. Any interactive system can be described through the composition of a set of instances of this model. In the case of context-dependent interactive systems, this model is still valid, the main change is that the trigger and input elements can be generated not only

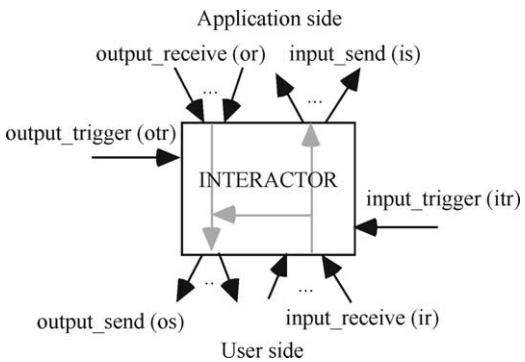


Fig. 1. An abstract view of an interactor.

by an interaction with a graphical interface, just as in traditional desktop settings, but also by some change or interaction in the surrounding environment (for example: a new person has arrived nearby, a change in lighting, a certain level of activity has been achieved, the user has arrived in a given location).

Further issues for designers and developers are raised by the increasing availability of new types of interaction platforms. Discussing the future of user interface tools, Myers, Hudson, and Pausch (2000) indicate that the wide platform variability encourages a return to the study of some techniques for device-independent user interface specification, so that developers can describe the input and output needs of their applications, so that vendors can describe the input and output capabilities of their devices, and so that users can specify their preferences. Then, the system might choose appropriate interaction techniques taking all of these into account. The basic idea is that instead of having separate applications for each device that exchange only basic data, there is some abstract description and then an environment that is able to suggest a design for a specific device that adapts to its features and possible contexts of use.

A possible solution is addressed by the TERESA environment (http://giove.cnuce.cnr.it/teresa.html), Mori et al., 2003, which helps designers to develop nomadic Web applications through its capability to support various abstraction levels: the tasks, the abstract user interface where objects are identified according to their semantics, the concrete interface where the specific interaction techniques are identified, and the code. Composition of the interaction objects is carried out according to the type of communication effects that designers aim to achieve (grouping, relation, hierarchy, etc.). In the refinement process, the tool is able to take into account the type of platform targeted and its multi-media capabilities and preserve usability. This is achieved by taking into account platform-dependent design criteria that help in the selection of the interaction techniques, their composition, and their dynamic behaviour. Recent contributions to better understanding how to design applications for specific platforms have been useful to understand the differences in designing for stationary desktops and mobile devices (Kaikkonen and Roto, 2003). In this process, an analysis of the tasks that can actually be effectively supported by each platform is fundamental (Paternò and Santoro, 2003). Many relations can occur: same task on multiple platforms in the same manner; tasks meaningful only on a single platform type; dependencies among tasks performed on different platforms, same task on multiple platforms but performed in different manners.

Once the multi-platform applications have been delivered, it is important to support dynamic migration among platforms in order to allow users to change device while accomplishing a task. For example, a user browsing the net with a PDA touch screen or a mobile phone keypad would be more comfortable using the mouse and keyboard of a stationary PC. Conversely, a user may be entering personal data through a stationary PC and wish for the greater privacy afforded by a PDA. Different types of run-time migration can be identified, along with different levels of complexity for each one of them. In *Total Migration*, the application migrates completely from one device to another. In *Control Migration*, the application is divided into two parts, one for managing user interactions (control part) and one for information presentation (presentation part). The control part remains on one device, while the presentation migrates to the other device, or vice versa.

Finally, *Mixed Migration* involves splitting the application into several parts, concerning both control and presentation, which are then distributed over two or more devices.

## 4. Conclusions

The rapid spread of interactive mobile devices has required profound rethinking of the main concepts in designing and developing interactive systems. Such systems can be accessed in many contexts of use through a wide variety of interactive platforms. The ability to adapt to them should be provided by tools for design and should be supported at run-time. The papers in this special issue and those mentioned in the references can provide useful suggestions to all those who aim to address such issues.

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