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2nd Workshop on Multi-User and Ubiquitous User Interfaces 2005 (MU3I 2005)

in Conjunction with the International Conference on

Intelligent User Interfaces 2005

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Workshop W2: Multi-User and Ubiquitous User Interfaces (MU3I 2005)

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ABSTRACT

This second workshop on Multi-User and Ubiquitous User Interfaces aims at further investigating two major issues identified at last year's MU3I: control and consistency. The former relates to how a user gains control of devices in a ubiquitous computing environment, how control is passed, and how it is shared in such a setting. The second one concerns interfaces that span multiple devices or move from one set of devices to another. Both issues will be discussed in this year's workshop (with a focus on consistency.)

1. SCOPE

The Ubiquitous Computing paradigm has the potential of drastically changing the way in which users interact with computers by providing (virtually) ubiquitous access to services and applications through a large number of cooperating devices. However, in order to make this vision come true and to realize a consistent and easy-to-use interface a number of (new) challenges have to be met, e. g.

- shared use of multiple services by multiple users using multiple devices
- spatial, temporal and conceptual consistency of user interfaces
- new 'devices' such as tags or everywhere displays
- new UI paradigms such as tangible, physical and hybrid UIs, and new UI metaphors for bridging the physical and virtual world
- spatial and temporal mappings between real and virtual world
- dynamic set of devices (i. e. people moving in and out)
- dynamic adaptation among several dimensions: devices, users, services
- restrictions of technical resources in the environment
- virtual characters as moderators, mediators and /or contact personas
- tracking and modeling social behavior and protocols

While there are already a number of ubiquitous user interfaces out there, last year‘s MU3I workshop at IUI helped us to identify several central problems that need further investigation. One major issue is the consistency of an interface across multiple devices: How can we build interfaces, which span multiple devices so that the user knows that they can be used to control a specific application? How do we avoid information overload, interference and ambiguity? How do we best guide attention from one device to another when they are used in the context of the same application?

2. CONTENT

This workshop is a follow-up on the workshop organized at last year's IUI, where a number of issues were identified that still needed further investigation. We discussed several different applications and their interfaces but it is still unclear how multiple colocated users would interact with a number of these applications simultaneously. This applies especially to control issues (e.g. who may use what device at any given time?) and its sociological implications (e. g. how is control negotiated between people? How can this negotiation be monitored?). A second major issue identified at last year‘s MU3I concerns the consistency of an interface across multiple devices: How can we build interfaces, which span multiple devices so that the user knows how they can be used to control a specific application?

Hence, the first session will focus on consistency discussing topics such as life-like characters as mediators, cross-device consistency of automatically generated user interfaces and presentation management. The second session will discuss a broader range of question including group-support and the scrutability and adaptivity of ubiquitous interfaces. For more information and to download accepted papers, please refer to `http://www.mu3i.org`.

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Schedule and Table of Contents

The Virtual Room Inhabitant

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ABSTRACT

In this paper we describe a new way to improve the usability of complex hardware setups in Instrumented Environments (IEs). By introducing a virtual character, we facilitate intuitive interaction with our IE. The character is capable of freely moving along the walls of the room. In this way, it may offer situated assistance to users within the environment. We make use of a steerable projector and a spatial audio system, in order to position the character within the environment. Our concept of a virtual character "living" within the IE, and thus playing the role of an assistant, allows both novice and advanced users to efficiently interact with the different devices integrated within the IE. The character is capable of welcoming a first time visitor and its main purpose is to explain the setup of the environment and to help users while interacting with it.

CONCEPT

Intelligent Environments physically combine several different devices. These devices are spread all over the environment, and some may even be hidden in the environment. As Towns et al. [4] have shown, virtual characters capable of performing judicious combinations of speech, locomotion and gesture are very effective in providing unambiguous, realtime advice in a virtual 3D environment. The goal of the project discussed in this paper, is to transfer the concept of *deictic believability* [4] of virtual characters in virtual 3D worlds to the physical world, by allowing a virtual character to "freely" move within physical space. The idea of a Virtual Room Inhabitant is to allow the character to appear as an expert within the environment which is always available and aware of the state of each device. In this way, the character can facilitate the user's work in the Instrumented Environment.

REALIZATION

In order to realize our vision of a lifelike character "living" in our IE, several software/hardware components were combined (see figure 1). Each device has to be registered on our device manager as a service. The device manager, in combination with a presentation manager, grants access to all registered devices. In this way, we are able to share our devices between several applications running simultaneously.

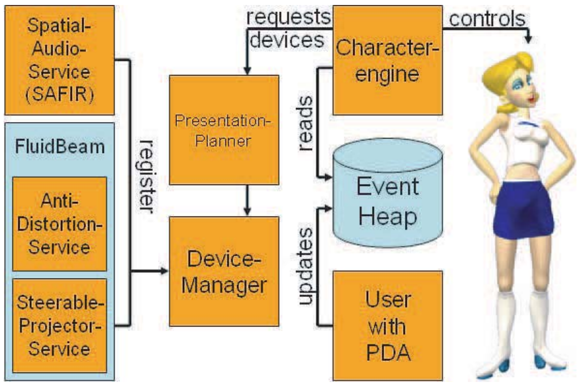

Figure 1. The system components of the VRI

To detect user positions we use two kinds of senders: Infrared beacons (IR beacons, allowing us to detect both position and orientation of the user due to the fact, that they demand a direct line of sight between sender and receiver) and active Radio Frequency Identification tags (RFID tags, as a backup mechanism, when the IR beacons are obstructed), both detected by the user's PDA. The calculated position is then forwarded by the PDA via wireless LAN to an Event Heap [1], where we collect all kinds of information retrieved within the environment (i.e. user positions, interactions with the system). Our central component, the character engine, monitors the Event Heap and automatically reacts according to changing user positions.

The Virtual Room Inhabitant (VRI) implementation is a combination of three components that will be explained in the following subsections: A character engine, a spatial audio system and a steerable projector, which allow the character to freely move within the room (i.e. move along the walls of the room).

Character Engine

The character engine consists of two parts, namely the character engine server (CE-server) written in Java and the character animation, which was realized with Macromedia

Flash MX[1]. These two components are connected via an XML-Socket-Connection. The CE-server controls the Flash animation by sending XML commands/scripts. The Flash animation also uses the XML-Socket-Connection to send updates on the current state of the animation to the CE-server (i.e. whenever a part of an animation is started/finished).
The character animation itself consists of ∼9000 rendered still images which were transformed into Flash animations. Whenever we have a demand for a certain gesture (or a sequence of gestures), the CE-server sends the corresponding XML script to the toplevel Flash movie which then sequentially loads the corresponding gesture movies. In addition to its animation control function, the CE-server also requests appropriate devices from the presentation manager. Once access to these devices has been granted, the CE-server controls the spatial audio device, the steerable projector and the anti distortion software.

Steerable Projector and Camera Unit (Fluid Beam)

A device consisting of an LCD projector and a digital camera placed in a movable unit is used to visualize the virtual character. It is mounted on the ceiling of the IE and can be rotated horizontally and vertically. In this way it is possible to project at any walls and desk surfaces in the room. The digital camera can provide high resolution images or a low resolution video stream which are used to recognize optical markers or simple gestures.
In order to avoid distortion due to oblique projection we apply a method described in [3]. It is based on the fact that projection is a geometrical inversion of the process of taking a picture given that the camera and the projector have the same optical parameters and the same position and orientation. The implementation of this approach requires an exact 3D model of the environment, in which the projector is replaced by a virtual camera.
In this way we create a sort of virtual layer covering the surfaces of the IE on which virtual displays can be placed. The VRI is implemented as a live video stream texture on a virtual display. Thus it can be animated in real time by the character engine. By moving the virtual display in the 3D model and an appropriate movement of the steerable projector the character appears to float along the walls of the room.

Spatial Audio Framework for Instrumented Rooms (SAFIR)

SAFIR runs as a service in our environment and allows applications to concurrently spatialize arbitrary sounds in our lab. The CE-server now sends the generated MP3 files and the coordinates of the current location of the character to the spatial audio system, which positions the sounds accordingly. The anthropomorphic interface obviously appears more natural with the speech being perceived from the same direction as the projection is seen. This is particularly helpful in situations when other applications clutter up the acoustic space with additional audio sources at the same time: The spatial attributes of the audio output of the virtual character allow the user to associate the speech with the projection of the avatar more easily. Furthermore it naturally directs the user's attention to the position of the character when it appears outside the user's field of vision.

[1]http://www.macromedia.com/software/flash/

CONCLUSIONS AND FUTURE WORK

While in the first phase of the project, we concentrated on the technical realization of the VRI, in the second phase we will focus on the behavior and interactivity of the character. To adapt the character's behavior to the user, we will integrate a combination of interaction history and external user model. While the interaction history will allow the character engine to adapt the presentations by relating to previously presented information, the external user model (which is available on the internet[2]) will allow the system to adapt to general preferences of the user (for example, a user might prefer to always use the headphones attached to his PDA, instead of a public audio system). To improve the flexibility of the approach, we will also allow the character to migrate from the environment to the PDA (this technology/concept is discussed in detail in [2]). In this way, the character will be capable of presenting personalized information to the user, while other users are in the same room.
In addition to adapting the application to multiple users we can create a personal virtual assistant for each of the potential users. Of course this only makes sense in a scenario with a limited number of users like for example a small office. Each character would have its particular appearance and voice, so that it can be easily recognized by the corresponding user.
In larger environments with plenty of users (like a shopping mall) it does not make sense to create a new character for each new user, but in this case the virtual assistant can call the attention of a particular user by addressing her or him by her or his name, which can be stored on the Event Heap together with other personal information.
The VRI has been successfully tested during many different presentations at our lab and we believe it is a promising first step towards an intuitive interaction method for Intelligent Environments.

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[2]http://www.u2m.org

Managing Presentations in an Intelligent Environment

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ABSTRACT

Intelligent environments enable users to receive information from a variety of sources, i.e. from a range of displays embedded in those environments. From a services perspective delivering presentations to users in such an environment is not a trivial task. While designing a service it is, for example, not clear at all which displays will be present in the specific presentation situation and which of those displays might be locked by other services. It is further unclear if other users are able to see the presentation, which could cause problems for the presentation of private information in a public space. In this paper we propose a solution to this problem by introducing the concept of a presentation service that provides an abstraction of the available displays. The service is able to detect conflicts that arise when several users and services try to access the same display space and provide strategies to solve these conflicts by distributing presentations in space and time. The service also notifies the user by a alarm signal on a personal device each time a presentation is shown on a public display in order to disambiguate content between multiple users.

Keywords

Smart Environments, Public Displays, Shared use of multiple services by multiple users using multiple devices

INTRODUCTION

The project REAL is concerned with the main question: How can a system assist its user in solving different tasks in an intelligent environment? We have developed two applications, which proactively provide a user with shopping assistance and navigational aid in response to their actions within the environment, minimizing the need for a traditional GUI, but the user can also use their PDA to formulate multimodal requests using speech and gesture combined. System output, such as directions and product information, is presented to the user in a flexible fashion on suitable public displays nearby to the user, based on the requirements of the content and spatial knowledge about the positions of the displays and the user. In such a scenario of multiple users, applications, and displays, conflicting presentation requests are likely to arise and need to be resolved.

In the following, we briefly describe the architecture of our intelligent environment before we explain the presentation service in detail.

THE SUPIE ARCHITECTURE

In order to investigate intelligent user interfaces based on implicit interaction and multiple devices, we have set up the *Saarland University Pervasive Instrumented Environment* (SUPIE). Its architecture has been designed for the seamless integration of the shopping assistant *ShopAssist* [5] and the pedestrian navigation system *Personal Navigator* [4]. It is organized in four hierarchical layers, which provide in bottom-up order: blackboard communication (based on the *EventHeap* [3] tuplespace), positioning and presentation services, knowledge representation and the applications. The presentation service will be explained in more detail in the next section.

Knowledge Layer

The knowledge layer models some parts of the real world like an office, a shop, a museum or an airport. It represents persons, things and locations as well as times and events. The ubiquitous world model *UbisWorld*[1] describes the state of the world in sentences made of a subject, predicate and object. A hierarchical symbolic location model represents places like cities, buildings and rooms, and serves as a spatial index to the situational context. In order to generate localized presentations and navigational aid, the positions of the user, the landmarks and the displays have to be known. Therefore the symbolic model is supplemented by a geometric location model, which contains coordinates of the building structure, landmarks, beacons and displays, and even their viewing angles and distances, if necessary.

Application Layer

Currently three applications employ the presentation manager in order to present information to the user on public displays. The *shopping assistant* provides product information and personalized advertisements to the user. As the user interacts with real products on the shelf, their actions are recognized by a RFID reader and in response, the assistant proactively serves product information to the user on a display mounted at the shopping cart. A wall-mounted display allows the user to browse through the vendor's product website, which opens automatically.

The *navigation application* runs on a PDA and picks up beacon signals, which are send to the positioning service

[1] www.u2m.org

and result in a location identifier. The handheld provides a visualization of the location on a graphical map and offers navigational aid by arrows and speech synthesis. It additionally utilizes the presentation service in order to present directions to the user on nearby public displays.

Another application welcomes the user as they enter the shop by a steerable projection of a virtual character.

More applications, such as the posting service *PlasmaPoster* [1] or the messaging service *IM Here* [2], could also easily benefit from the presentation service and run simultaneously in the environment.

MANAGING PRESENTATIONS ON MULTIPLE DISPLAYS

In a public space with various displays we assume that a number of applications are running simultaneously and concurrently attempting to access display resources. Therefore we favour World Wide Web technology, such as HTML and Flash, for presentations that still allow simple form-based interaction, instead of running custom applications on the public displays. Whereas canonical conflict resolution strategies could be first come, first served or priority based assignments of display resources, we focus on rule-based planning: Presentation strategies are modelled as a set of rules that are applied to a list of available displays and queued presentation requests. These rules generate plans at runtime, which define where and when presentations are shown. Applications post their presentation requests on the blackboard, which include the following mandatory and optional(*) arguments:

Source	URL of the content
Destination	Display *or* location *or* user
Type	Image, text, video or mixed
Expiration Deadline	e.g. in 30 minutes from now
(Minimum Display Time)*	e.g. 60 seconds
(Minimum Display Size)*	Small, medium, large
(Minimum Resolution)*	e.g. 800x600
(Audio Required)*	Yes, No
(Browser Input Required)*	Yes, No

Based on these requests, the presentation service plans the presentation schedule for all displays in a continuous loop:

1. Generate a list of feasible displays based on their properties and spatial proximity to the users' location.
2. Sort the list according to: idle state, minimum requirements (e.g. size), general quality and release time.
3. Resolve conflicts by queuing requests (division by time) and splitting displays (division by screen space).

This set of rules provides coherent presentations in public spaces and resolves conflicts by dividing display resources in time and space: Presentations are scheduled according to their deadline requirements and are delayed until resources are available (time). Screen space is shared if an appropriate device is available such that presentations are rendered simultaneously on the same screen in different windows (space).

Privacy issues require additional rules: Each user can specify contents as private within the user model, for instance all navigational aid. The presentation service would now simply remove displays in the first step which can be seen by other users.

Conflicts that arise from multiple users interacting concurrently can be handled by the same strategies. However from the users' perspective, it is crucial to be aware of presentations intended for them and to avoid confusion caused by similar presentations for other users. Therefore the presentation service notifies the user via a personal device by an alarm signal (e.g. mobile phone vibration), that is synchronized with the appearance of the presentation on a public display. If no such notification device is available, the presentation service can automatically tag the content with a personal graphical icon or sound that is stored in the user model.

IMPLEMENTATION

We have implemented Internet Explorer-based presentation clients for Windows CE and 2000, running on various public displays, including PocketPCs as interactive office doorplates, a tablet PC connected to a shopping cart, and wall-mounted panel PCs and plasma displays.

The presentation service currently resolves conflicts by considering the deadlines combined with priorities. It matches the display positions with the user's current range of perception, and presentations are queued until displays become available or multiple browser windows are opened (division in time and space). A rule-based planner is currently under development in Prolog.

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Discussing groups in a mobile technology environment

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ABSTRACT

Intelligent presentations in a mobile setting, such as a museum guide, tend to deal with the problem of providing appropriate material for the individual in the specific situation. In this paper we discuss intelligent group presentations, that take into account the fact that members of groups will interact also among themselves, during and possibly after the relevant experience.

Keywords

Guides, groups, presentations, communication.

INTRODUCTION

The title of this paper is ambiguous on purpose: on one hand we address the future of group presentations in a mobile setting, starting from achievements obtained in the context of Intelligent User Interfaces; on the other hand we mean to hint at the fact that members of groups will not just have an interaction with the technological artifacts, but also among themselves, during and possibly after the relevant experience. The technology we discuss is originally conceived for a mobile cultural heritage setting, such as a visit to a museum or to a historical city. Though various works have been conducted aiming at sophisticated and adaptive presentations for the individual, giving away with traditional presentations that are intrinsically the same for all or for large groups of visitors, we should be aware of the irony: mostly people come to visit such places in groups. Will intelligent interface technology be able to help and perhaps to exploit this fact to achieve the end goal, namely a better way of learning, getting interested, and enjoying the experience?

It should be noted that our view has a potential also for other mobile learning settings such as a factory or an environment critical area, where a group of new workers have to get acquainted with the environment.

CURRENT RESULTS

Various projects have introduced technology for individual presentations. The technology typically takes advantage of some localization system (for instance based on devices that generate an infrared signal from fixed positions, or based on triangulation through emitters/receivers of wireless digital signals, or on very sensitive GPS systems, nowadays working also inside buildings). The visitor has a small portable device (for example a PDA), and can receive information relevant to the particular site.

The interesting thing is that the profile of a visitor can be known to the system, and the system knows where the visitor has been and what has been his path through the physical site and what has been presented to him. More in general a dynamic user model can be built in the course of the visit. This opens the possibility of offering a presentation tailored specifically to the individual visitor. The presentation can then possibly exploit different modalities (for example spoken language and graphics on the PDA screen, or pictures, or dynamic videos to produce a personalized documentary).

Another potential is exploitation of multiple devices, for example combining a personal, wearable device, with the possibility of having a portion of a presentation being delivered on a large, good quality display. A step experimented then is to allow seamless transition from one device to the other, granting coherent presentations across devices [1]. It is characteristic of this scenario that input complexity tends to be limited. The Sottovoce project [2] has proposed a multimedia mobile guide that supports pairs while visiting together a museum. The guide does not involve neither adaptivity nor intelligent presentations. Krueger et al [3] have discussed dealing with presentation on a big fixed screen, complemented with information provided on small personal devices. The idea is that the "cocktail-party-effect" may allow following presentations on multiple media at the same time, and that a common presentation may be complemented by notes delivered on an individual device, and possibly be dynamically adapted to take into account the interest of the majority in the audience.

THE SOCIAL ASPECT: HUMANS WILL INTERACT

What we are interested in is presentations that are meant for a group of people that are moving in a space, emphasizing the fact that they are not just a collection of people but persons that will communicate during the visit and possibly afterwards. They will share emotions, they will provide and follow advice, they will integrate the acquired information, and they will discuss points of view. After all, the goal is that people would get more interested in the subject, that they may wish to go deeper into it and, if possible at all, that they are hooked and will wish to come back to the site again. Thus we bring into consideration groups of people that come together and may possibly have a social relation, such as a family, or groups that come together with a specific learning goal, such as a classroom. Necessarily these groups are bound to have some interactions after the visit. Groups that are just assembled on the spot (like visitors that happen to be at the same moment at a site where a common presentation is yielded) may still have occasional interactions, but normally they depend on the character and attitude of the individuals. For this latter case the use of technology can be along the lines experimented in COMRIS [4].

SMALL GROUPS

Members of a small group visiting a cultural site are equipped with personal presentation devices. Still everyone may decide on his own what to do and how to proceed at any moment. All presentations are to be personalized on the basis of a user model. The user model starts with an initial profile and evolves dynamically along the visit. Visitor's actions, both communicative toward the system and in the physical environment are interpreted, as well as the history of the current visit are used for the development of this personal user model. Two types of information are to be provided on an individual device:

a) Basic, infrastructural information specific to the fact that that there are other individuals in the group. From the technological point of view among things we can have are

- visualization of the position of other members of the group;
- messages to other members of the group (normally we do not want to have spoken messages in such a setting, and often coded information should be enough, without needing a keyboard): coded messages for informing about a point of interest for the others, including an automatic presentation of the point on the map; messages for setting a meeting at the sender location with an indication about how to reach it from the current position; messages for stating it is time to go and meet at the entrance; etc.
- information about the overall level of enjoyment of the members of the group (available from the individual user model: an interface for communicating the present state of the user is for instance available in PEACH).
- virtual *postit*'s that can be left at given sites with comments that can be received by other individuals.

b) Personalized presentations about the artifacts on display. Differently from what happens in the single presentation, now the system is aware about the state of all the members of the group: what they have seen, and what they have been presented with, and how interested they have been at the various moments. There are basically two ways of adapting the presentation. The first is adapting *for* the group, and can be realized following the lines proposed by Krueger et al [3]. The second is adapting *in* the group. The system can prepare a presentation $P_{i,t1}$ for the individual x_i at time t1 and when appropriate prepare a presentation $P_{j,t2}$ to a different individual x_j with information that will complement $P_{i,t1}$.

The actual narration in the specific presentation $P_{i,t1}$ must now take into account the fact that not everything will be told. A basic tool in narration is building an expectation in the audience and at some later time release tension fulfilling (or possibly contradicting, with a surprise effect) the expectation. Now we want the answer to this expectation to be in the hand of some other member of the group, so that later interaction will be needed and satisfactory. The system can also exploit social roles (e.g. something different can be expected from a parent then from a child in a subsequent interaction). If needed, especially with children, a motivating game can be used for favoring subsequent interaction.

Technology for addressing the mobile group scenario

As for point a), in our initial experimentation we are adopting an agent based software infrastructure, LoudVoice/NetVoice[5], that allows overhearing of communications, and is the backbone for adding all kind of devices and collaborative or competing modules. The graphical interface on the PDA can appropriately convey the message.

For point b) two aspects are essential:

- reasoning on the interests, the state and location of the members of the group, on the knowledge related to objects on display, and on the material that has been presented or is going to be presented to the other members so that the group of agents that support the group of individuals can negotiate the "distributed" presentations. For this we are currently experimenting the use of SharedPlans [6].
- preparing individual presentations on the basis of the preceding point. The multimodal narration structure, experimented in our PEACH environment for the individual will have to be adapted.

What about large groups?

Large groups normally have a learning task and should have a phase in which they experience some collective presentation, similarly to what discussed by Krueger et al [3]; then divide into small groups as discussed above, either with an explicit task or guideline, or totally left to the individual initiative.

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Cross-Device Consistency in Automatically Generated User Interfaces

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INTRODUCTION

The growing importance of ubiquitous computing has motivated an outburst of research on automatic generation of user interfaces for different devices (*e.g.*, [6] or our own SUPPLE [4]). In some cases, care is taken to ensure that similar functionality is rendered similarly across different applications on the same device [5]. However, we also need to ensure that after using an application on one device (say, a PDA) and having learned that user interface, the user will not have to expend much effort having to learn a brand-new user interface for the same application when moving to a new platform (*e.g.*, a touch panel). We have began to extend our SUPPLE system in a way that allows it to produce interfaces that make a trade off between optimality given a new platform and similarity to the previously rendered user interfaces for the same application. In particular:

- we show how to incorporate an interface dissimilarity metric into a UI generation process resulting in new interfaces resembling ones previously used by the user;
- we propose a list of most salient widget features that can be used to asses similarity of interfaces rendered on radically different platforms;
- and we outline the most promising approaches for automatically learning parameters of a UI dissimilarity function from user feedback.

INTERFACE GENERATION AS OPTIMIZATION

We cast the user interface generation and adaptation as a decision-theoretic optimization problem, where the goal is to minimize the estimated user effort for manipulating a candidate rendering of the interface. SUPPLE takes three inputs: a *functional interface specification*, a *device model* and a *user model*. The functional description defines the *types* of data that need to be exchanged between the user and the application. The device model describes the widgets available on the device, as well as cost functions, which estimate the user effort required for manipulating supported widgets with the interaction methods supported by the device. Finally, we model a user's typical activities with a device- and rendering-independent *user trace*. Details of these models and rendering algorithms are available in [4].

We have now extended our cost function to include a measure of dissimilarity between the current rendering ϕ and a previous *reference* rendering ϕ_{ref}:

$$\$(\phi, \mathcal{T}, \phi_{ref}) = \$(\phi, \mathcal{T}) + \alpha_s \mathcal{S}(\phi, \phi_{ref})$$

Here, $\mathcal{T}$ stands for a user trace (which allows SUPPLE to personalize the rendering), $\$(\phi, \mathcal{T})$ is the original cost function (as in [4]) and $\mathcal{S}(\phi, \phi_{ref})$ is a dissimilarity metric. The user-tunable parameter α_s controls the trade-off between a design that would be optimal for the current platform and one that would be maximally similar to the previously seen interface (see Figure 1).

We define the dissimilarity metric as a linear combination of K *factors* $f^k : \mathcal{W} \times \mathcal{W} \mapsto \{0, 1\}$, which for any pair of widgets return 0 or 1 depending on whether or not the two widgets are similar according to a certain criterion. Each factor corresponds to a different criterion. To calculate the dissimilarity, we iterate over all elements e of the functional specification $\mathcal{E}$ of an interface and sum over all factors:

$$\mathcal{S}(\phi, \phi_{ref}) = \sum_{e \in \mathcal{E}} \sum_{k=1}^{K} u_k f^k(\phi(e), \phi_{ref}(e))$$

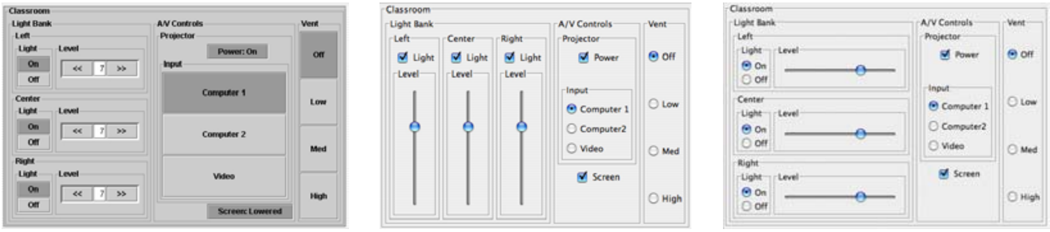
In the following two sections we will discuss what widget features we have identified as good candidates for constructing the factors and how we can learn their relative weights u_k.

RELEVANT WIDGET FEATURES

To find the relevant widget features for comparing interface renderings across different platforms, we generated interfaces for several different applications for several different platforms and we picked sets that we considered most similar. We have identified a number of widget features sufficient to explain all the results we generated. The following are the features of primitive widgets (*i.e.*, widgets used to directly manipulate functionality):

Language {toggle, text, position, icon, color} – the primary method(s) the widget uses to convey its value; for example, the slider uses the position, list uses text and position, checkbox uses toggle.

Domain visibility {full, partial, current value} – some widgets, like sliders, show the entire domain of possible values, lists and combo boxes are likely to show only a subset of all possible values while spinners only show the current value.



(a) (b) (c)

Figure 1: A basic example: (a) a reference touch panel rendering of a classroom controller interface, (b) the rendering SUPPLE considered optimal on a keyboard and pointer device in the absence of similarity information, (c) the rendering SUPPLE produced with the touch panel rendering as a reference (the dissimilarity function parameters were set manually).

Orientation of data presentation {vertical, horizontal, circular} – if the domain of possible values is at least partially visible, there are different ways of arranging these values.

Continuous/discrete – indicates whether or not a widget is capable of changing its value along a continuous range (*e.g.*, a slider can while a list or a text field are considered discrete).

Variable domain {yes, no} – the domain of possible values can be easily changed at run time for some widgets (*e.g.*, lists), while it is not customary to do it for others (*e.g.*, sets of radio buttons).

Primary manipulation method {point, type, drag} – the primary way of interacting with the widget.

Widget geometry {vertical, horizontal, even} – corresponds to the general appearance of the widget.

We will omit here the features of container widgets (*i.e.*, those used to organize other elements) because they mostly have to do with obvious widget properties, such as the layout and visibility of sub elements.

LEARNING THE DISSIMILARITY METRIC

We aim to find values of the parameters u_k for the dissimilarity metric that best reflect the user's perception of user interface similarity. We propose to do it by automatically learning these parameters by asking user explicit binary queries (*i.e.*, "which of the two interfaces looks more like the reference rendering?"). We will learn rough estimates of these parameters by eliciting responses from a significant number of users in a controlled study. This will allow SUPPLE to behave reasonably "out of the box" while still making it possible for individual users to further refine the parameters. We are thus looking for a computationally efficient learning method that will allow SUPPLE to learn from a small number of examples and that will support efficient computation of optimal or near optimal binary queries.

One very elegant approach to this problem is to treat the parameters u_k as random variables [2], whose estimates are updated in response to the gathered evidence by inference in a Bayes network. This approach makes it very easy to encode prior knowledge and it provides an intuitive mechanism for integrating accumulating evidence. However, there is no compact way to represent the posterior distribution using this approach so, in theory, it may be necessary to keep a full log of all of user's feedback and re-sample the model after each new piece of evidence is obtained. Also, it is notoriously hard to compute optimal queries to ask of the user when reasoning about the expected value of the target function (although efficient methods have been found for some well defined domains, *e.g.* [3]).

Methods based on *minimax regret* allow the factors u_k to be specified as intervals and learning proceeds by halving these intervals on either side in response to accumulated evidence. These methods are particularly attractive because computationally efficient utility elicitation methods have been developed within this framework [1]. The main drawback of this approach is that it is not robust in the face of inconsistent feedback from the user.

An algorithm based on a standard method for training support vector machines has been proposed for learning distance metrics from relative comparisons [7]. This method may likely produce the best results, although an efficient method would need to be developed for generating optimal queries so that appropriate training data could be obtained with minimal disturbance to the user.

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Generating Consistent User Interfaces for Appliances

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ABSTRACT

We are building a system called the *personal universal controller* (PUC) that automatically generates interfaces for handheld devices that allow users to remotely control all of the appliances in their surrounding environment. Within this system, we are interested in two forms of consistency: with other interfaces on the same handheld device and with previously generated interfaces for similar appliances. We have done some work on multi-device consistency, but it is not our focus. This paper presents three questions that we believe must be answered in order to achieve both multi-device and previous interface consistency. The importance of these questions is justified in the context of our PUC system.

Keywords

Automatic interface generation, consistency, Pebbles, appliances, personal digital assistants (PDAs), smart phones, personal universal controller (PUC)

INTRODUCTION

The *personal universal controller* (PUC) system [4] attempts to improve everyday appliance user interfaces by moving them from the appliance to a handheld device, such as a PDA or smart phone. A key feature of the PUC system is that it automatically generates its user interfaces from an abstract description of the appliance and a model of the handheld device. Our current system is implemented on Microsoft's PocketPC and Smartphone platforms, and we have used it to control a number of real and simulated appliances, including shelf stereos, media players, non-driving vehicle functions, and elevators. We are currently working on a new feature that will allow the PUC system to generate user interfaces that are consistent with previously generated interfaces. This will allow an interface for a user's new VCR, for example, to be consistent with the familiar interface of that user's old VCR.

Our main focus is on consistency with previously generated interfaces, but PUC interfaces are also made consistent in two other ways: with other interfaces on the user's handheld device and with other interfaces for the same appliance on different devices. We have already addressed the first type of consistency by using standard interface toolkits and ensuring that our automatic generation rules conform to user interface guidelines for the device on which we are generating interfaces. We have also addressed the multi-device consistency problem by using similar generation rules on different platforms (see Figure 1), and by using familiar idioms, such as the conventional play and stop buttons for media players, with a technique called Smart Templates [5].

We have identified several questions that we think must be answered in order to automatically generate consistent interfaces:

- How can interfaces be consistent when they contain different sets of similar functions?
- What dimensions of consistency are important and what is their relative importance?
- How often must a function be used before the user will benefit from consistency?

This paper will show how these questions are relevant to the consistency issues that we are facing with the PUC system. Though we are not focused on multi-device consistency, we believe that our work, especially by answering these questions, will be beneficial for achieving multi-device and previous interface consistency.

INTERFACE CONSISTENCY IN THE PUC SYSTEM

We have found that the problem of generating interfaces that are consistent with previous interfaces can be broken down into two sub-problems: finding previously generated interfaces that are relevant, and determining how to make the new interface consistent with those previous interfaces. We will only discuss the second sub-problem here.

The first issue with generating a consistent interface is to find the functions that are similar across the previously generated appliance and the new appliance. We expect that some of the functions, such as play and stop, will be identical, but that each appliance will have some functions that are unique. In order to ensure consistency, we will need an answer to our first consistency question.

One answer may be based upon how similar functions are grouped across appliance specifications. There seem to be

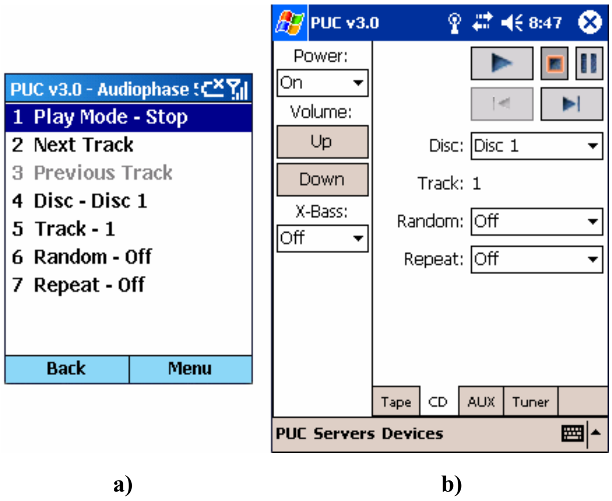

Figure 1. Two examples of interfaces generated by the PUC system for a) the Microsoft Smartphone and b) the PocketPC.

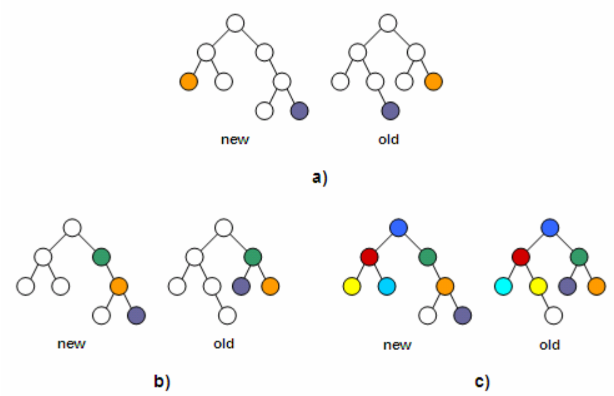

Figure 2. Examples of the three different levels of similarity, with trees representing the structure of the new and old interfaces and same shading indicating similar functions. a) *sparse,* b) *branch,* and c) *significant.*

three important groupings, which we have termed sparse, branch, and significant (see Figure 2). Each suggests a different technique to achieve consistency. Appliances with sparse similarity will try to represent each similar function with the same interface controls that the user saw in the older interface. Appliances with branch similarity will try to integrate into the new interface the layout and organization of the related functions in the previous interface. Appliances with significant similarity will try to replicate the same layout and organization in the new interface that the user has seen in previous interfaces.

One of the difficulties of the branch and significant similarity cases is deciding how to deal with the few functions that are not shared across interfaces. The rules that we use to create consistent interfaces will need to take into account the different dimensions of consistency that are relevant and the relative importance of those dimensions. For example, an important question to answer here is the importance of two dimensions of consistency: visual vs. structural. Two interfaces would be visually consistent if they had a similar appearance, and structurally consistent interfaces would require users to navigate the same series of steps to reach the same functions. If visual consistency is very important to users, then we might choose to leave the controls in the new interface for features that were only available on the old appliance. If visual and structural consistencies have about the same importance, then controls for unavailable features might be replaced with controls for features that are only available on the new appliance.

There has been some relevant work done on dimensions of consistency, both for desktop interfaces [2] and multi-device interfaces [1], but work is needed to turn these theoretical ideas into concrete rules for interface generation.

We also believe that actual usage is important for deciding when and whether to ensure consistency. An important question that we have not addressed is how much must a user interact with an interface before they will benefit from consistency? How recently must a user have interacted with an interface before the benefits of consistency begin to degrade? Some of this information may be suggested by models of human performance [3]. We also plan to conduct user studies to evaluate these issues.

CONCLUSIONS

We are currently extending our PUC system to enable generation of interfaces that are consistent with previous interfaces the user has interacted with. We are also addressing the multi-device consistency problem. We believe that these two problems share many of the same features and that solving one will suggest solutions for the other.

ACKNOWLEDGMENTS

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Marker-Based Interaction Techniques for Camera-Phones

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ABSTRACT

We propose a framework that establishes new user interaction metaphors for camera-phones based on the orientation of the camera relative to a visual marker and based on optically detected phone movements. The approach provides a powerful way to use camera-phones as mediators between the real and the virtual world by defining spatial and temporal mappings between the both. The conceptual framework can be applied to media such as paper and electronic displays.

INTRODUCTION

Detecting visual markers with mobile devices is a common approach today. A simple example is a mobile phone with an attached barcode reader for scanning product identifiers. Yet this input capability is limited in that it just produces a single identification number.

We propose an extension to visual marker detection that takes the mobile phone's orientation and the targeted area into account. In this way, multiple information aspects can be linked to a single visual marker. Marker-based input thus becomes richer and more expressive, which enhances the user interface capabilities of mobile phones.

We have developed a conceptual framework that establishes new user interaction techniques for camera-phones based on the orientation of the camera relative to a visual marker and based on optically detected phone movements. The framework provides versatile ways to interact with mobile information services that are associated with objects in the user's environment, such as augmented board games, product packagings, signs, posters, and large public displays.

In particular, a number of interaction primitives are defined, which can be combined to form more complex interactions. An interaction specification language allows to define rules that associate actions – such as textual, graphical, and auditory output – to certain phone postures. A stateless interaction model allows to specify interaction sequences. It guides the user by providing iconic and auditory cues.

VISUAL CODE SYSTEM

The visual code system described in [1] and [2] forms the basis for the proposed interaction techniques. The recognition algorithm has been designed for mobile devices with limited computing capabilities and is able to simultaneously detect multiple codes in a single camera image.

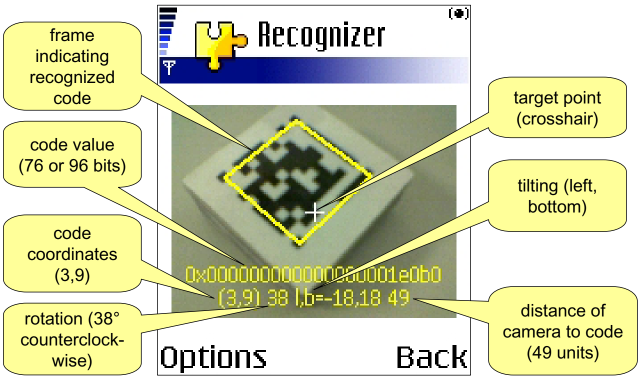

Figure 1. Visual code parameters.

In addition to the encoded value, the recognition algorithm provides a number of further parameters. These include the rotation of the code in the image, the amount of tilting of the image plane relative to the code plane, and the distance between the code and the camera. Figure 1 shows all of the code parameters as displayed in a testing application written in C++ for Symbian OS. Since no metric values are computed, the camera properties are not required, i.e. no calibration step is necessary to compute the additional parameters.

An essential feature of the visual code system is the mapping of points in the image plane to corresponding points in the code plane, and vice versa. With this feature, the pixel coordinates of the camera focus, which is the point the user aims at and which is indicated by a crosshair during view finder mode, can be mapped to corresponding code coordinates. Each code defines its own local coordinate system that has its origin at the upper left edge of the code and that is independent of the orientation of the code in the image. Areas that are defined with respect to the code coordinate system are thus invariant to projective distortion.

INTERACTION TECHNIQUES

A number of basic building blocks, called *interaction primitives*, can be used to construct combined interactions. There are *static interaction primitives* (see table 1), which require the user to aim at a visual code from a certain orientation and stay in that orientation, and two kinds of *dynamic interaction primitives*, which involve "sweeping" the camera across a visual code or simply moving it relative to the background. The *pointing* static interaction primitive involves focusing a certain information area, such as the cell of a table. *Stay* requires the user to stay in a certain posture for a predefined time. A combination of both could specify that focusing the area shows initially information aspect x and, after the time specified in the *stay* primitive, shows information aspect y.

To facilitate information access and to indicate the possible interaction postures, each interaction is associated with one or more *interaction cues* in the form of visual or auditory icons. They are shown on the mobile device's display depending on the current phone posture. For instance, the leftmost *rotation* interaction cue in table 1 indicates to the user that the phone can be rotated either clockwise or counterclockwise in order to access further information. The rightmost cue for the *distance* primitive means that more information can be obtained by moving the phone closer to the code – relative to the current posture.

The term *input capacity* in table 1 denotes the number of discrete information aspects that can be conveniently encoded in each of the interaction primitives. It is a measure of how many discrete interaction postures can be easily and efficiently located and selected by users. These values have been found experimentally and during user testing.

Static interaction primitive	Input capacity	Interaction cues
pointing	number of information areas	information area is highlighted
rotation	7	
tilting	5 (+4 if using NW,NE,SE,SW)	
distance	8	
stay	unlimited (time domain)	(icon has a highlighted display)
keystroke	12 (keypad) + 5 (joystick)	(icon has a highlighted keypad)

Table 1. Static interaction primitives.

With the *sweep* dynamic interaction primitive, the phone is moved ("swept") across the code in a certain direction while the camera is in view finder mode. The direction of movement is sensed by the mobile device and used as the input parameter. The second kind of dynamic interaction primitive is based on an optical movement detection algorithm and does not require a visual code in the camera view. It provides linear (x,y) movement and rotation around the z-axis. It is not suited for discrete input, but for continuous adjustment of parameter values or for direct manipulation tasks.

The basic interaction cues are designed in such a way that they can be combined to form more complex interaction cues. Table 2 shows some possible combinations of two static interaction cues. When the mobile display shows a combination interaction cue, this means that the user has a choice to select between more than one interaction primitive to reach further information items. Even with combinations of only two static interaction cues, a large number interaction possibilities results.

area & keystroke	+ highlighted area	**tilting & keystroke**	
rotation & tilting		**distance & stay**	
rotation & distance		**distance & keystroke**	

Table 2. Combinations of interaction primitives.

Static interaction primitives can be combined with dynamic movement interaction primitives. Even if they cannot be executed simultaneously, performing a dynamic after a static interaction primitive is possible. A user first selects a certain parameter using a static interaction primitive – like tilting – and then uses relative linear movement to adjust the associated value. The relative movement detection is activated while the user is holding the joystick button down. This kind of combination resembles a "click & drag" operation in classical GUI interfaces.

Combined interactions are described in an XML-based specification language that is downloaded onto the phone using the code value. It relies on a stateless user interaction model that determines how a user can browse information or trigger actions in combined interactions. "Stateless" means that the model only considers the currently sensed parameters.

APPLICATIONS

The interaction techniques could be used, e.g., to couple mobile information services with product packagings. In addition to the extended input features, the code coordinate system allows to register graphical overlays or even animations with items printed on the packaging. Board games could also be augmented using the proposed techniques. Individual cards of a strategy game, e.g., could be equipped with visual codes. Complex rules and dynamic processes could then be computed by the mobile phone. Various interactions could trigger specific game operations. On large public displays, the techniques enable rich interaction possibilities without the need to install input hardware in public space.

OUTLOOK

We think that the proposed conceptual framework enables expressive ways of interaction with objects in the user's environment mediated by camera-phones. At the workshop, we will present the techniques in more detail and discuss them as well as potential applications.

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Preliminary Evaluation of Ubicomp in Real Working Scenarios

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INTRODUCTION

Hospitals are complex information-rich environments that include a significant technical and computational infrastructure; the need for coordination and collaboration among specialists with different areas of expertise; an intense information exchange; and the mobility of hospital staff, patients, documents and equipment. This makes them ideal application environments for pervasive or ubiquitous computing technology.

Not surprisingly evaluating ubicomp systems is a difficult challenge as it often requires costly and complex implementations [1]. In our work we aimed to evaluate in a cost-effective way the core characteristics of an ubicomp environment that integrates interactive public displays and PDAs with context-aware hospital applications [3]. In the next section we briefly describe this environment.

SYSTEM DESCRIPTION

The context-aware hospital information system addresses the following aspects:

1) Ubiquitous access to medical information. The medical staff may access medical information from several ubiquitous devices, such as a PDA or a public display. For instance, a physician may request a lab analysis from his PDA, and later, he may visualize lab results from a large-public display to discuss them with a colleague.

2) Context-aware access to relevant medical information. To provide relevant information for users, our system takes into account the contextual information, such as user's identity, role, location, device used, time, and status of an information artifact (e.g. availability of a lab result). Thus, when a physician, carrying a PDA, is near to one of his patients, then the system presents clinical information.

3) Awareness of user's location and devices. The system enables users to be aware of other users' location and devices' status. This information is displayed as a list or in a map in the user's PDA or a public display. The users' location is estimated by reading the signal strength of the PDA to the wireless access points [5].

4) Content adaptation and personalization. Contextual information is also taken into account to adapt and personalize the presentation of information to the user. Thus, when a user approaches the public display, it shows only the patients assigned to her, messages addressed to her, and the location of users and device with which she may require to interact.

5) Collaborative Work. In a hospital, physicians often ask for second opinions, or need other specialist to help them solve a problem. The system supports this by showing a map where the user can locate coworkers, send messages to them, and share an application or lab studies.

6*) Information transfer between heterogeneous devices:* The context-aware hospital system enables users to transfer information from public spaces to personal spaces. For instance, after two colleagues discuss a clinical case by using the public display, one of the physicians may want to keep a link to this case in his PDA for further review. The user only needs to drag the information to her picture in the display to transfer information between the display and her PDA as showed in the figure 1.

Figure 1. A resident working with a PDA and then collaborating with a male nurse on a public display.

STUDY DESIGN

The study was conducted at IMSS General Hospital in Ensenada, Mexico. The subjects of study were 35 people, 24 were residents and the rest of them were doctors.

We evaluated the acceptance and use of technology through video scenarios, which were designed as a result of a three months case of study in the same hospital. Three scenarios, showing real working situations augmented with ubicomp were produced and two of them used in the evaluation session. Roles in the videos were played by hospital personal to make them more realistic.

PROCEDURE

An evaluation session lasting about an hour included the following phases:

Phase 1: A 10 minute introduction.

Phase 2: Three video sequences were shown to the participants: A 5 minute video explained the main features of the system, and 2 videos showed scenarios of use of the technology. Figure 1 shows a scene from one such video. The aim of this was to put in context the use of the technology to the medical staff. Following this, we performed a live demo showing them the features of the system. A Q&A session followed the videos.

Phase 3: In this phase the participants were asked to complete a survey with 7 Likert-scale assertions, which included topics such as their perception on how realistic were the problems presented on the scenarios, the obstacles to adopt these technologies in the hospital and, finally, the perception of ease of use and usefulness of the proposed system.

Phase 4: Finally, the subjects were given time to freely use the technology.

The entire session was videotaped. Comments while using the devices were also collected.

RESULTS AND DISCUSSION

Here we present some results obtained through the survey.

Obstacles for the adoption of the technology

Figure 2 shows the main obstacles foreseen in the use of the technology. The subjects identified lack of training as the main potential obstacle, followed by the hospital's ability to acquire the technology and the availability of appropriate technical support.

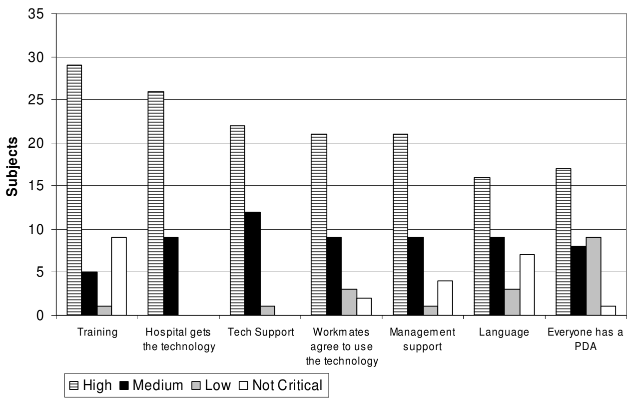

Figure 2. Obstacles for adopting ubiquitous technology

Comparison between current vs. proposed practices

We asked the subjects to assess the usefulness of the ubicomp environment to address threes significant problems they face everyday in their working environment: asking for a second opinion; locating co-workers; and sending and receiving alerts the availability of the results of clinical test. They all agreed that these are actual problems they face everyday and are not adequately addressed by current technologies. They felt that the ubicomp technology shown to them would be significantly better than their current solution.

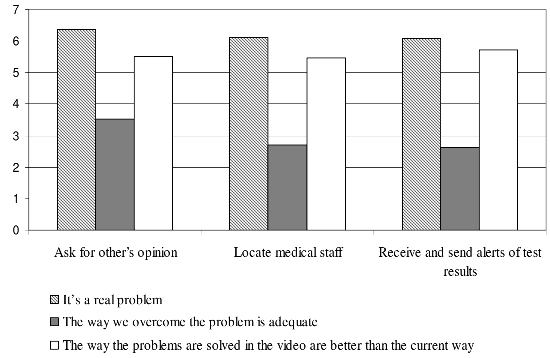

Figure 3. Current vs. proponed practices

Perception of ease of use and usefulness

The questionnaire included questions to asses the subjects' perception of usefulness and ease of use of the technology, which according to TAM [2] are important predictors of system's use. The participants found the technology to be useful (5.6 in a 7 Likert-scale) and easy to use (5.8), which indicates that they might indeed use the technology, and has motivated us to initiate an adoption phase.

CONCLUSIONS

The potential advantages of ubiquitous technologies cannot always be perceived until the users are situated within a new context of interaction. Preliminary evaluation of ubicomp based on video-scenarios is then an ideal mechanism to go beyond current practices and let users to get involved in the design process and the envisioning of novel schemes of application while remaining relatively simple and inexpensive. We consider that this process is fundamental for ubicomp when applied to large spaces of interaction such as hospitals. Our evaluation also promotes a consideration of challenges beyond those purely technical. As our results indicate obstacles for adopting those technologies should be brought to the process of design and be managed in a sensible way in order to guarantee the success of an implementation.

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Natural Support for Multi-User High Definition Visualization and Collaboration

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ABSTRACT
In this paper, we present a platform that enables multiple people to interact naturally, using touch and gesture, with a large, high resolution display. The display presents and supports coherent applications, rather than collections of disparate video sources. These same applications may also be presented across a variety of devices, making this a robust platform not just for data visualization and manipulation, but also multi-site communication and collaborative work based on a shared view. We will discuss our initial findings in the area of large scale multi-user GUI design, as well as our future work on the platform and related applications.

Keywords
collaboration, visualization, interactivity

INTRODUCTION
Technologies such as ERP systems and sensor networks have laid the foundation for systems that give greater visibility into complex human organizations, on finer time scales. Such systems will be able to supply real-time insights to assist decision-makers with complex decisions and optimizations.

However, as the decisions become more complex, they often involve input from a larger number of experts and viewpoints. The resulting situation is that a growing number of people must collaborate over a growing amount of data in order to take action.

There are relatively few tools that directly address the needs of collaborators simultaneously interacting with a large display. Those that do are typically aimed at users with a high level of technical proficiency, sometimes expecting the user to be skilled with specialized tools such as 3D pointing devices or stereoscopic glasses[1]. Such expectations may limit the system's usefulness. In practice, users typically want to focus on the content of the problem, and not on the visualization or collaboration technology itself.

With these points in mind, we have created a platform that is designed specifically to display very high-resolution applications, on a scale large enough for multiple people to see and use. The surface of the display is touchable, so that users can interface with the software using natural point and touch actions. Our approach is simple; the platform should allow you to *see* the data, *use* the data, and *share* the data.

The platform is based on a software toolkit, which we designed, that scales to create arbitrarily large workspaces. The first instantiation of this platform was a 10ft x 4ft, 4096x1536 pixel screen, with cameras mounted along its bottom edge to support high-resolution touch. This instantiation is the subject of the remainder of this document.

CREATING A SHARED VIEW OF DATA
Large format data walls are in common use today, with several approaches to how they display content. One approach is to mount a large number of display adapters in a single workstation, but this generally comes with a substantial performance penalty. Another is to use a video "fusion" processor[2], which carries a large financial cost. Finally, a distributed system such as Chromium[3] parallelizes operations, but requires low level driver changes and doesn't fully support all the features of a GPU. In all cases, these approaches only address the problem of rendering to a large surface.

We have taken a different approach. We actually distribute the task of rendering a large application to a number of cooperating (commodity) machines. Each machine is responsible for drawing a "slice" of the overall canvas. Developers write software, using our C++-based API, as if their canvas were actually the size of the target display (in this case, 4096x1536). But at runtime, multiple copies of their entire code are executed, in parallel, on the various machines. Our framework automatically keeps the state of these various machines sychronized, using a simple, lightweight networking layer. Input events—touches on our display, for example—are broadcast to all devices.

Therefore, our platform works at a level of abstraction that is higher than Chromium's distributed OpenGL calls. We maintain synchronization among a collection of independent devices working in parallel to render different aspects of the big virtual canvas. What the user sees is simply a single coherent application. The devices themselves share a coherent view of the canvas and the user's interactions upon it. If a bouncing ball is animating from one end of the canvas to the other, and there are four machines driving the display, there are actually four balls executing in code, one for each machine. But at any one time, at most two machines are actually rendering the ball.

SUPPORTING NATURAL ACTIONS

If one casually observes a group of people collaborating around a set of physical assets such as blueprints or models, one will see a large amount of touching, pointing, and hand motions. Ideally, a technological approach should accommodate that style of natural and comfortable interactions. However, in most cases, the opposite seems to be true. Many large visualization walls offer no direct manipulation tools at all (see photos at [4]).

Touch screens are not, in themselves, novel. However, most touch screens are only available in limited form factors. Generally, touch sensitive plasma screens are not large enough to be used by several people at once. Smart Boards[5] offer a large form factor, but relatively low data density. And the majority of these devices function through a mouse driver, thereby inheriting the limitations of a mouse, such as only supporting one pointer at a time.

Our system allows users to interact with the entire 10ftx4ft, 4096x1536 surface, detecting input with a resolution that is limited mainly by the size of the human fingertip. The device also supports multiple simultaneous users, as shown in Fig. 1.

Figure 1

Thus far, we have created applications meant to illustrate how a platform like this would be used in data-intensive business domains, managing such systems as an airline's realtime CRM, a utilities infrastructure, or, as in Fig. 1, a manufacturing supply chain.

INITIAL FINDINGS AND DISCUSSION TOPICS

At this time, the project is less than a year old and we are still experimenting with several aspects. However, it is clear that the value of a system as described above can only be realized if the applications are specifically designed to take advantage of the unusual features and capabilities. In general, we wish to discuss and explore approaches to this problem. To facilitate that discussion, we've listed some initial observations below.

- WIMP design rules do not necessarily apply to the applications built on this platform. Menus and other static click targets might be physically far away from some users.
- The interface and visualization should be usable from two different distances (somewhat like a newspaper is). When users stand back, a large display should give them a usable "big picture" view. When they are close enough to interact, the application should supply fine-grain information.
- Most GUI events models (and most collaborative software) assume that the actions of individual users will be somehow serialized. We are only beginning to explore the GUI and interface rules for a system with truly parallel user input.
- We have found that support for simple gestures such as point, poke, and wipe can be very useful, but we have avoided any gestures that would require training for the user. We are interested in exploring and enumerating the body of "natural" gestures that would be intuitive to anyone using the wall display.

CONCLUSION

We believe that our platform offers a unique mix of information density, interactivity, and collaboration support. As such, it represents a new set of issues and research opportunities. We are interested in exploring these issues and opportunities in the larger context of similar applications present at the workshop.

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Tabletop Support for Small Group Meetings: Initial Findings and Implementation

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ABSTRACT
In this paper, we present our initial design and implementation of a tabletop device to support small group meetings. This work is part of a larger project, called CHIL, funded by the European Commission to study multimodal support to human-human group activities. In designing our application, we pursued a strict User-Centered Design approach by conducting user observations on natural group meetings and focus groups with participants. Both the observations and the focus groups were aimed at eliciting a number of dimensions relevant for the design of a multimodal support to meetings and in particular to inform the design of a tabletop application.

Keywords
Guides, instructions, author's kit, conference publications

INTRODUCTION
Technologies to support human-human collaboration have always been a hot topic for computer science. Meetings in particular represent a stimulating topic since they are a common, yet at the same time problematic, human activity. One of the seminal studies to inform design of technology to support meetings is [4]. The aim of that work was to inform the design of an application to support remote meetings yet the author described observations to real face-to-face meetings. Since then, the list of published works on remote meetings is so long to discourage any attempt to synthesis.

In the last years, the emergence of hardware able to support, at least partially, multi-users raised the interest in technologies to support face-to-face collaboration [5]. Chen and colleagues in [7] proposed the use of DiamondTouch, a real multi user touch device to support co-located interaction. They proposed a circular interface to solve the problems of the different users' point of view around the table. Users manipulated the objects on the projected display by touching the devices with the fingers. Kray and colleagues [2] discuss several issues that arise in the design of interfaces for multiple users interacting with multiple devices with focus on user and device management, technical concerns and social concerns. Finally, the AMI and M4 European projects are investigating multimodal support to meetings [1].

ETHNOGRAPHY AND FOCUS GROUPS
Four sessions of natural meetings by 3 groups were video recorded at the premises of our institute. All the meetings were scheduled and conducted independently from the purposes of the project; the only constraint imposed was that a whiteboard be laid down horizontally on the table, to simulate a tabletop device (see figure 1).

Fig. 1. Interaction with an horizontal whiteboard during the initial observations

All the meetings were video recorded by three cameras, one placed above the whiteboard and other two facing on the participants. All the recordings were analyzed by three annotators using MultiVideoNote, a video annotation tool developed at ITC-irst that allows simultaneous view of up to three video streams, and permits to attach notes to frames (http://tcc.itc.it/research/i3p/mvn/). All the meetings were recorded for approximately 60 minutes, though in almost all cases the actual meeting proceeded beyond this time. After each session, the three annotators met to discuss and reach an agreement on the observations. Three focus groups were conducted to elicit participants' opinions on some of the dimensions emerged from the observations, with a particular emphasis on the use of the horizontal whiteboard, and on the experience of being videotaped. It is worth noting that the purpose of the observations was to inform the design of the entire multimodal support system and not the tabletop device only.

The fundamental functionalities of a tabletop device that emerged from the study were the need of using a pencil rather than the finger to operate the table; the necessity of organizing the space both functionally (see also [5]) and to manage the limited space; and the usefulness of organizing tools like the agenda or the final “to do list”, at least in some context. Orientation emerged as a problem in the focus group (see also [6]) although it did not look problematic in the observations. The necessity to manage public, private and semi-private spaces also emerged (see also [5,6]). A longer discussion on the findings can be found in [7].

THE PROTOTYPE IMPLEMENTATION

Following these requirements, we decided to base the design of our system on the concept of virtual sheets of paper that can be opened and used by the participants. Each sheet can be shrank or moved to save space and can be rotated to be made accessible to all participants. Participants can use the pen to draw or write while a keyboard is provided to write longer texts. Import and export functionalities enable the participants working on already prepared sketches as well as starting from white sheets. Two sheets of papers have special functions: the agenda and the “to do” list. The former contains the issue to be discussed. Issues can be added, removed or sorted. Each issue can be active or inactive. The system displays a time counter on the active issue; the counter is paused when the issue is made inactive.

Fig. 2. Users interacting with the prototype

The “to do” list allows to keep track of the decisions taken during the meeting. Each entry is automatically associated with the agenda issue currently active (if any) and, through drag-n-drop, to one or more documents. Management of private and semi-private spaces is tackled by allowing a tunneling from the table and the personal laptops of the participants. Finally, the orientation issue is not coped with by a circular interface as in [6]. Instead, in order to optimize the use of space we provided a mirroring functionality, that is, the content of the table is also projected on the wall with an automatic re-alignment of the sheet in order to make visible all the space to the group.

Our initial prototype was designed for the DiamondTouch to have the advantages of the multi-user support, but then we moved to Mimio (a commercial tool based on infrared and ultrasound) because of the requirement using a pencil rather than the finger to operate the device.

CONCLUSION AND FURTHER WORK

Although an extensive user evaluation is not already started, we have conducted two short qualitative studies with two groups of people. In both cases, the users were able to use the basic functionalities of the table even if the top projection creates some problems for drawing. Also, the use of Mimio created some problems: it is quite slow in general and if the position of the hand hides the sensors, the system does not work very well. All the participants recognized that the tabletop device allows a natural face-to-face interaction while providing a better support for managing the space. The possibility of importing and exporting was considered very useful.

In order to assess the usability and the usefulness of the table a more detailed evaluation is planned in the next months. We think that an other major benefit for the users will be the not-yet-implemented functionality of automatic minute’s production using the information in the agenda.

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A Scrutable Museum Tour Guide System

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ABSTRACT
This paper aims to address the problem of providing a consistent conceptual interface across multiple devices in a ubiquitous computing environment. The scenario described in this paper is that of a personalised museum tour guide that adapts the description and information about exhibits to the visitor. We proposed a solution that utilises domain ontology to aid in conceptual consistency of the contents and interfaces in the museum and discuss our approach using existing systems.

Keywords
Scrutable system, museum guide, user model, adaptive hypertext, scrutability, ontology, visualisation

INTRODUCTION

This paper discusses the issues of providing an interface for users in a museum that provides enriched information about the exhibits they are viewing, much like a tour guide, as well as letting them have a sense of control over the system. An interface would be required on both handheld devices and information terminals. We propose the notion of a scrutable domain ontology to provide a consistent conceptualisation that underpins the museum exhibits, the personalised content delivered to users across the devices, and also the user models in the adaptation system.

We start by presenting the scenario in a more concrete form, then discuss our approach to providing an infrastructure to tackle this problem, and finish with some discussion points and a summary of the issues raised.

SCENARIO

A group of school students in an ancient history course has a field trip to the Nicholson Museum at the University of Sydney, which specialises in archaeological artefacts. The teacher uses a user modelling server that keeps track of each student's understanding of the material taught in class. The day before the visit, the teacher sends the user models for the students to the museum's curator.

On the day of the visit, students receive a PDA to use during their viewing of the exhibits from museum staff. Students input their name and password to get their own personalised descriptions of the exhibits, adapted from the user models the curator received earlier.

Wilbur is a student, very keen on the characters and heroes through out history, and his user model indicates this. The PDA shows him a presentation tailored for him at the section of *Troy* - *The Age of Heroes*. As he holds his PDA near the vase, it displays descriptions of the characters depicted on the vase, and allows him to follow links to further details about the characters. As an option, the system allows him to see what aspects of the description have been adapted to him and what evidence has been used to make the predictions. As it turns out, the system falsely indicated that he knew about the assassination of *Prince Troilos*. Wilbur corrects this and the system re-renders the description about *Prince Troilos* to better suit his understanding. The system keeps an implicit personal history profile of what he has seen and updates the user model accordingly (similar to existing systems, for example in [1]).

Marion, another student from the class has a strong interest in sculptures, so the system recommends a tour with different periods and styles of carvings and statuettes. A history of the exhibits she has seen is automatically kept, and a higher level of comprehension of the overall structure of the field is provided as she progresses. After watching a very concise introduction to a piece of ancient Greek earthenware, Marion is not fully convinced by the adaptation the system provided. She decides she needs to examine why the system decided to adapt the information that way for her and goes to an information post to acquire a rich visualisation of her user model. She realises the system assumes she knew about that particular artefact, so she decides to correct this. After satisfying her curiosity and modifying some preferences in her user model, Marion gets a revised tour recommendation.

After the visit, the class has a group discussion sharing the adaptive tour each person had. They also show images of exhibits they saved during the visit.

ONTOLOGIES AND THE MUSEUM

An ontology explicitly describes the concepts and relationships in a domain [2]. It is common for a museum to (and certainly most unusual not to) have small descriptions to accompany each exhibit. It would therefore be useful to be able to utilise these descriptions to generate an ontology of the museum artefacts. We have been developing a tool, MECUREO [3] which can analyse and collate domain documentation (such as the exhibit facts) to create a lightweight domain ontology.

The vocabulary of the ontology forms the basis for the domain concepts in the user model, and the relationships can be exploited by the adaptation system to perform intelligent customisations. The ontology structure can also be exploited as a means to visualise the user model. So in our approach, the ontology not only critical to the core part of the system, but it is easily understandable, as the relationships and concepts all link back to a human readable (and editable) domain glossary.

USER MODELLING

Actions by the user are stored in the user model as evidence to allow the system to create adaptations to enrich their experience of the visit. Based on this evidence, which, in effect, represents an “interest level” in the contents of the exhibits, the system would tailor the information delivered to suit the individual. The different tastes of Wilbur and Marion in the scenario is an example.

The user modelling server, Personis [4], allows adaptive systems to easily manage evidence for user models. It provides a resolution system to perform customisations based on this evidence as well as supporting scrutability. The same resolver can be accessed by different devices, with the results tailored at the device level to be appropriate to the interface.

THE MOBILE INTERFACE

We have been developing a version of the Scrutable Adaptive Hypertext system [5] that integrates the Personis user modelling server. The web-based interface, adaptability, and controls for scrutability make it a suitable for the nomadic interface depicted in the scenario.

Selections to a set of multiple-choice questions constitute an initial user model which is then managed by the Personis server. Each page is tailored to user, and some pages may be omitted if the user is not deemed ready to view them. At any time the user may choose to see how the page currently viewed is adapted to her or him. The text being included or excluded is highlighted with different colours. By moving the mouse cursor over each section of the highlighted text, the reason for inclusion or exclusion is provided. If the user is unsatisfied with the personalisation, they may correct it instantly.

STATIC INFORMATION DEVICES

Larger information terminals placed around the museum can not only provide users with additional details about the exhibits but also allow an access point to their user model. These terminals often have a touch screen or a small keyboard meaning that interfaces to the user model should be easily controlled through limited input. It would be useful in such interfaces for visitors to be able to get a quick overview of their user model and at the same time be able to easily drill down for further information.

The Scrutable Inference Viewer (SIV) [6] is one such interface for visualising ontologies and user models that can be easily manipulated on a pen/touch driven device. For the museum scenario, users would be able to select or remove concepts from a *tour set* **-** inferences can be made on this set to find a suitable tour for the user.

DISCUSSION

We have illustrated our goal in terms of a scenario where our system is underpinned by a central lightweight ontology. This is automatically constructed from existing domain documentation. It provides a consistent conceptualisation of the domain, and in turn, leads on to a consistency in the ubiquitous interfaces.

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The Influence of Unpredictability on Multiple User Interface Development

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ABSTRACT

As ubiquitous computing environments are characterized by openness, heterogeneity, and dynamics, their developers have to deal with the fact of not knowing all about the system's future environmental setting at development time. This has especially influence on the user interface development. In this paper we discuss and raise questions about the influence of unpredictability on the development of multiple user interfaces.

Keywords

Ubiquitous computing, multiple user interfaces, user interface generation, unpredictability.

MOTIVATION

Nowadays, ubiquitous computing provides more and more users access to an increasing number of services from an also increasing number of devices in different environmental contexts. Thus, the diversity of *usage situations*, as a combination of users, services, contexts, and devices, is getting more and more complex through the enormous number of possible values of every single factor. By devices, for instance, we refer to a computing platform as a combination of computer hardware, an operating system, and a user interface toolkit [8]. This definition covers traditional desktop workstations, laptops, personal digital assistants (PDAs), as well as mobile phones. Additionally, the numbers of devices increases recently even faster, and even very small devices are getting more and more powerful. This applies in similar form for the other three factors users, services, and contexts.

The complex diversity of usage situations is a great challenge already and much research is done in this area, including topics like model-based user interface design, context-aware user interfaces, multimodal user interfaces, and multi-user interfaces.

Since especially ubiquitous computing environments are characterized by openness, heterogeneity, and dynamics, it is important to take into account the fact of not knowing all kind of possible usage situations at development time of the user interface. Particularly the characteristic of user interface adaptation to all kind of devices, user characteristics, services, and contexts is crucial to let visions like ambient intelligence [7] become reality in near future.

In the following section we take a more detailed look at some issues about the influence of unpredictability on the development of multiple user interfaces.

THE INFLUENCE OF UNPREDICTABILITY

As we assume that the unpredictability of usage situations will influence many user interface development activities, we start with the interface implementation phase. Although, we mostly illustrate the unpredictability by introducing new devices, we do not want to simplify the problem. It applies in similar form for the other three factors users, services, and contexts.

The consequence of the complex diversity of possible usage situations is that it is unscalable to implement a user interface for each usage situation by hand. Thus, an automated solution is necessary. A number of researchers have introduced techniques and tools as solutions for this challenging task, e.g. [1,2,3,4]. A commonly used method is multiplatform generation [3]. Here the user interface is generated for each platform needed, based on a platform independent model of the interface and a description of the platform specific constraints. The model needs to be as abstract as possible to guarantee a maximum of platform coverage. Apart from this abstract description of multiplatform generation, different implementation of this process can be found, which are differently influenced by unpredictability.

[2,3] centre the design effort on one source interface, designed for the less restricted device (e.g. powerful PC with large display) and conditions or rules to this interface, to produce other interfaces for more restricted device (e.g. mobile phones). An important prerequisite of this approach is the identification of the less restricted device. But how can this device be identified, if not all devices are known at

development time? How does this approach deal with the fact that a lesser restricted device, in comparison to a chosen source device, will occur during the lifetime of the system? Can additional rules handle this situation or do all rules have to be adapted according to a new source platform? If a new device is more restricted than the chosen source device, an automatic generation of a user interface on this device is still impossible because the new device was not known at development time and thus, no transformation rules exits. Even if all possible devices are known at development time, the identification gets rather complicated if multiple device interfaces are taken into account instead of single device interfaces [6]. How can the "best" combination be identified?

Another important decision in the generation process is how the final interfaces will be actually rendered. Are the devices themselves responsible for the actual rendering [4] or will there being a central unit that renders the interfaces according to a given profile [1,2]? In the latter case, the question where the profiles will be administrated occurs, additionally. How does the unpredictability of usage situations influence this design decision? In case of a central rendering unit, the interface to this unit needs to be capable of dealing with future devices. If devices render the interfaces themselves, their interfaces to the rest of the system needs to be specified clearly and as abstract as possible. Otherwise it will be impossible to introduce the device's new features, e.g. new interaction styles.

The last remark leads to a very important question in the context of multiple user interfaces: How do we specify the characteristics of a device, and in a more general sense, how do we specify the whole usage situation in detail? If we want to introduce new devices, it is crucial to have a specification that can deal with future device features, unknown at development time of the system. How the new device increases or decreases the functionality, performance, and usability of the whole system needs to be determined automatically.

All issues mentioned above deal with the implementation respectively the generation of the user interface. The following questions deal with other development activities which may be influenced by unpredictable usage situations?

- How does the design process itself look like and how many abstraction levels [3] of a user interface are influenced by the unpredictability of usage situations?
- Besides the pure feasibility of generating multiple user interfaces for unknown usage situations, how does the unpredictability influence the usability of the interface, especially as we do not know all possible users? How does the unpredictability influence user interface consistency?
- How can tool support look like?
- If HCI patterns [5] are used how can new patterns according to new devices, interaction styles, or user characteristics, are introduced in the system?
- How do we validate these systems with focus on the robustness against new usage situations? Even if new interaction styles or device visions exist at development time, they are at most in a prototype state and can not be used directly in usability evaluations. How will user involvement in the development process be influenced?

SUMMARY

We discussed and raised questions about the influence of unpredictability on multiple user interface development. We showed the influence on many development activities during almost all development phases with focus on the influence of unknown devices on the implementation phase. As we will not have time to discuss all questions during the workshop, we suggest discussing the following recapitulating question: How can we specify a stable interface between the user interface and other system parts that don't need to be changed even if the system's platform changes to a platform not known at development time?

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Reports

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