ubiController: Situation-aware Mobile User Interface for Ubiquitous Computing Environment[†]

Hyoseok Yoon and Woontack Woo
GIST U-VR Lab.
Gwangju 500-712, S. Korea
{hyoon,wwoo}@gist.ac.kr

ABSTRACT
In this paper, we propose a PDA-based situation-aware user interface called ubiController, for interacting with multiple services in a smart home environment. Situation-awareness is realized by interpreting a user's situation and using this interpretation to display an easy-to-use and relevant service control menu appropriate to a user's situation, in order to reduce the number of direct user interventions. Also ubiController supports interactions among multiple users through recommendation on conflict situations and personal media sharing. The proposed system can be an essential tool in the ubiquitous computing environment to help users establish an interaction doorway to pervasive services.

Author Keywords
Mobile user interface, universal controller, service discovery, situation-aware, multi-user interaction

INTRODUCTION
In ubiquitous computing environments, services are ubiquitous and multiple in numbers. Therefore, it is essential to provide a consistent contact point between a user and an environment. Here, user context, i.e. context derived from and by a user, can be utilized to tailor user-centered services which are otherwise fixed to target a majority of users. Numerous initiative studies have chosen mobile devices as the key interaction tool between users and the environment [1][2]. However, much of context-aware aspects and support for multiple users are neglected. In this paper, we introduce a situation-aware mobile universal interface called ubiController, which exploits implicit, contextual information about a user's situation to facilitate interaction with available services in the ubiHome testbed [3].

THREE FEATURES OF UBICONTROLLER
The proposed interface, ubiController, provides *controllability, multi-user interactivity* and *situation-awareness* to enable an easy interaction with multiple services and users in ubiquitous computing environments.

In this paper, we briefly touch on the first two features and focus on the *situation-awareness* feature.

- Controllability: To give a user control of an environment, we employ service discovery and universal control. ubiController discovers services as a control point in the environment using UPnP. Since UPnP does not support any context or semantic operability, we wrap the module in our ubi-UCAM (Unified Context-aware Application Model in ubiquitous computing environment) [4]. Service discovery notifies users for service functions and universal control mechanisms execute them.

- Multi-user interactivity: Context-aware services encounter problems when one user's request cannot be met due to another user's conflicting request. In such case, ubiController establishes a communication channel to resolve the conflict through recommendation. Moreover, ubiController supports sharing of personal contents with other users. Personal contents stored in mobile device can be shared through public display services, which allow multiple users to upload and download contents.

- Situation-awareness: A user's situation is represented in terms of his or her location, direction, and velocity retrieved from the location sensor. ubiController utilizes the situation of a user to create the relevant service control menus. Initially a pre-captured panoramic view of the testbed is sphere-mapped and displayed as a background image of the interface. Also GUI reflects a user's situation in an intuitive way. The background image rotates with a user's location to create an impression of navigating the environment and of location proximity. For example, a user can simply control the TV service by clicking the TV image displayed in the background while facing the real TV.

INTERPRETING THE SITUATION OF A USER
To use the situation of a user as an implicit input, we define the notion of 'relevancy' of a service in a situation

(Situation-Service Relevancy). First, a user's current situation is defined in terms of a set of attributes of the user's movement (location, direction, etc) and a service. With respect to currently available services, a user's situation is,

- *Irrelevant* when it has no influence on the service;

- *Negatively relevant* when it disables the service;

- *Minimally relevant* when it activates the service;

- *Operationally relevant* when it requires an operation of a subset of available controls of the service;

- *Maximally relevant* when it requires full control of the service.

The more relevant a user's situation is to a service (SSR), the more specific and detailed is the service control menu that is generated. With a user's current situation and its relevancy for each service, ubiController selects the service controls starting from the most relevant service and tailors the service control menu accordingly as shown in figure 1.
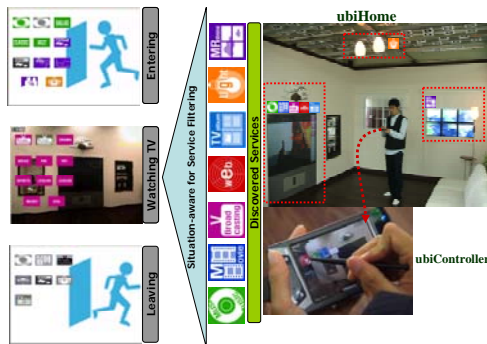

Figure 1. Situation-aware control menu.

For example, 'Watching TV' is described in terms of location, orientation, and velocity

Watching TV = {couch, facing toward TV, 0}

The representation and assignment of SSR can be defined flexibly by developers of context-aware services. In our exploratory implementation, this situation makes TV service maximally relevant, so the full TV control user interface is created by selecting all service control buttons from the TV service. In a similar fashion, a user's situation of "Entering the living room" and "Leaving the living room" can be represented with its corresponding values. The situation "Entering the living room", service control buttons are selected from the three services of different relevancy, namely operational relevancy for music service and display service and minimal relevancy for the light service. Different relevancy levels of each service contribute on determining the number of control buttons from each service to be displayed on the user interface. The situation "Leaving the living room", which is negatively relevant with all six services, is accordingly reflected by displaying *off* and *disable* buttons from each service. Figure 1 shows the service control menu augmented on the user

interface for situations of "Entering the living room", "Watching TV", and "Leaving the living room" respectively.

EXPERIMENT AND EVALUATION

The proposed system is deployed in the smart-home testbed of ubiHome. We evaluated how a user's situation can be used to reduce the number of explicit interventions by counting the number of clicks to do a task. We alternatively carried out using for our mechanism for situation-awareness (see table 1).

Situation	Task	Number of Clicks
Watching TV	Switch TV Channel	4
Entering	Turn on Lights	5
Leaving	Turn off 7 services	23

Table 1. Number of explicit user interventions.

To explicitly control services, the user is required to take several steps (clicking a device and selecting proper service can take up to 4 clicks depending on the design) whereas a user is only required to click only once with our system.

CONCLUSION

In this paper, we introduced ubiController, a situation-aware mobile user interface exploiting a user's situation for service filtering and interaction. ubiController supports *controllability* with service discovery and universal control for multiple services in the environment. *Multi-user interactivity* is supported through conflict notification, recommendation and personal contents sharing. *Situation-awareness* is supported by interpreting the situation of a user with respect to currently available services where different situations are categorized, in order to create intuitive service control menus. The proposed system is realized and tested in the ubiHome testbed and showed promising results for reducing the number of cases that require explicit user intervention. Open questions regard a refined representation of a user's situation and a more detailed study on which attributes of a situation to prefer for interpretation of a user's current focus of interest.

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