Augmented Interaction with Mobile Devices to Enhance the Accessibility of Ubiquitous Services

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Abstract

This paper introduces the design of an abstract model for enhanced sensor data to augment mobile user interfaces with semantic information. In addition to detailed information about sensors, the model contains rules for interpretation of data from diverse sets of sensors. This mechanism aims to produce a type of perception from the raw data provided by the sets of sensors currently active. The objective is to produce better adapted user interfaces and increased accessibility to ubiquitous services. This research is framed in the EGOKI generator of adapted user interfaces for ubiquitous services.

Author Keywords

Accessibility to Ubiquitous Computing, Sensor Fusion and Modelling.

ACM Classification Keywords

H.5.2 User Interfaces: *Input devices and strategies*.
I.2.9 Robotics: *sensors*.

Introduction

The popularization of portable smart devices, such as smartphones or tablets, is perceived as a key element for making advances in Ubiquitous Computing. Current

Requirements for Mobile Interaction with Intelligent Environments

To allow people with disabilities to have access to ubiquitous computing services, we have identified three main requirements:

1. User Interfaces to access each particular ubiquitous application must be accessible to each specific user.
2. Intelligent environments must have an open middleware that manages the recognition, the inclusion of the newcomers in the network, and the provision of ubiquitous services.
3. Both the hardware and the software of the mobile device operated by the user must be accessible.

mobile devices, which include several sensors, can access diverse types of wireless networks. . These sensing and connectivity features make them very well suited to capturing and monitoring the context of use. In addition, mobile devices appear to be a "natural" way to interact with intelligent environments. Users are accustomed to the handling and interaction style of their mobile devices. Moreover, people with disabilities usually have specific assistive software and hardware that facilitate the use and manipulation of their own devices.

Therefore, using peoples' devices to access pervasive computing systems very much enhance their accessibility. However, even accessible devices can present low usability because the interaction processes are frequently restricted (or redirected to different modalities) in order to ensure accessibility, making the interface slower and more complex. One of the objectives of our current research is the use of advanced sensors to augment and simplify the interaction, thus enhancing the user experience.

In this paper we recall the automatic generation of adapted user interfaces for an intelligent environment and propose an extension using internal and external sensors. The main requisites that must be fulfilled in order to make ubiquitous services accessible are listed in the sidebar. In the next section, an intelligent environment (INREDIS) [1] and its adapted user interfaces generator (EGOKI) [2] are presented. To conclude, our present research, aimed at augmenting mobile user interfaces to achieve better adaptation and to enhance accessibility, is discussed.

Background

The starting point of this research work is the INREDIS project, which is aimed at developing basic technologies to create communication and interaction channels between people with disabilities and their environment. For instance, it provides context-aware access to services such as ATMs or vending machines.

In a typical INREDIS scenario, a person enters an intelligent environment carrying a personal mobile device. The ubiquitous platform discovers and integrates the device into the network. Then, an accessible list of the available services is downloaded to the user's device. When one of the services is selected, a standard interface is downloaded to the device. However, the standard interface may not be suitable for people with specific disabilities. For this reason, our research group developed EGOKI, a model-based adapted user interface generator, as a part of INREDIS. Now, when one of the services is selected, a personalized accessible interface is downloaded to the device, allowing accessible operation of the service. EGOKI's features are described in the sidebar on page 3.

The management of discovery and interaction with ubiquitous services in the intelligent environment is performed by a standard middleware: an implementation of the Universal Remote Console (URC) called the Universal Control Hub (UCH) [3]. UCH allows heterogeneous devices to operate within the network.

The next section explains how adding new ways of obtaining context information has extended the scope of the EGOKI system. The interpretation of the information collected by combined sensors reinforces the adaptations that can be applied to the user

EGOKI features:

- Diverse models are used to generate personalized user interfaces: User, Device and Adaptation Models, built as an ontology; and a UI Model, specified by means of a User Interface Description Language (UIDL).
- It generates user interfaces for desktop and mobile Web browsers according to the WCAG guidelines and recommendations.
- To achieve modality independency, designers of ubiquitous services have to specify the functionality of the service and to provide interaction resources allowing diverse modalities, using an UIDL.
- The user interface to access each particular ubiquitous application must be accessible to each specific user, but not necessarily to all users.

interface. An overall view of the system can be seen in Figure 1.

Augmented user interaction through accessible mobile devices

As previously discussed, users with disabilities who are equipped with appropriate mobile devices can interact with ubiquitous services provided. In addition, recent advances in sensor technologies and mobile devices (e.g. smartphones) have made it possible to enhance or augment this interaction by applying the information collected from both external sensors and sensors included in the user's own mobile device.

Most smartphones integrate advanced sensors such as digital compasses, gyroscopes, accelerometers, GPS receptors, etc. The information collected by these sensors can be used to implement commands (e.g. turning the device from vertical to horizontal position makes the display change from portrait to landscape configuration). However, this information can also be used to adapt the user interface to the current conditions. For instance, localization can be used to adapt to the context. Movement patterns can suggest the context of use the mobile device (walking, sitting, driving…)[4].

In addition, sophisticated miniaturized sensors are available off-the-shelf at affordable prices [5]. Using these advanced sensors certain biological parameters (e.g. blood pressure, heart rate, skin conductivity, etc.) have traditionally been used to detect emotional reactions to the interaction.

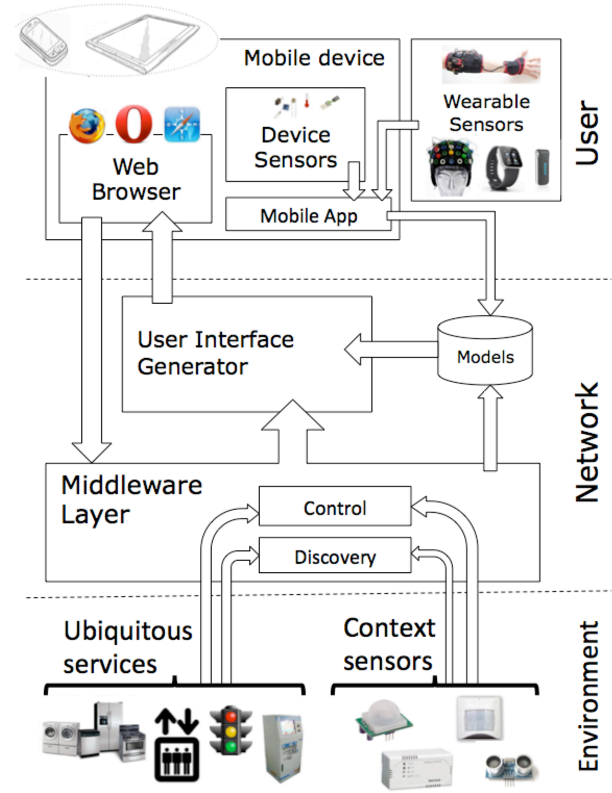

Figure 1. The proposed platform, showing the main elements and how they are connected.

There also exist portable brain activity sensors (that have been used for Brain-Computer Interaction with only relative success). Portable sensors that can detect muscle activity can also be used as input for some user interfaces [6]. These types of sensors are beneficial for people with motor impairments, enabling them to interact with mobile phones in a more suitable way.

Ubiquitous Scenarios

There are traditional ubiquitous scenarios that can be enhanced using the sensor combination approach presented in this work.

For instance, a smart traffic light that is able to negotiate longer times for the green light when a person with reduced mobility or vision is trying to cross a street.

Diverse combinations of available sensors obtain augmented contextual information such as the time the person needs to finish crossing the street or whether the user is approaching the correct crossing, by using the GPS, accelerometer and compass.

The electromyography (EMG), accelerometer and gyroscopes can filter involuntary movements allowing touch selections for people suffering from muscle spasm or tremor.

The combination of data collected from different sensors can provide more and better quality information. Diverse sensor fusion mechanisms allow us to take a step forward in abstraction, from sensing to perception [7]. These systems provide semantic interpretation of the data that is suitable for enhancing the interaction. In addition, raising the abstraction level allows designing for "abstract sensors" rather than for specific sensors, which are technology dependent.

Interpreting sensors

Our work is based on the state of the art in sensors ([4, 5, 6] among others). We developed a taxonomy of available sensors, including sensors integrated in smartphones, "worn" by the user, and located in the environment. From the analysis of their functional characteristics we created a model where sensors are grouped into clusters that can be jointly interpreted. This model is intended to produce high-level information on position, orientation, activity, etc., and even mood, which can be used either to feed the EGOKI User Model or to determine the current value of variable parameters such as direction, speed, etc. This is achieved by means of an ontology that contains the main characteristics of the sensors and a set of rules for the information that can be obtained from the combination of the currently available sensors for each particular situation. The next step in our research is to develop an application for mobile devices to feed the system with this augmented information.

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