SensAid Pad: Supporting Context-Aware Information Navigation

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Abstract. Designing and implementing ubiquitous information systems presents new challenges to software engineering. These systems have to integrate a variety of components representing both hardware and software to bridge the gap between the physical and virtual worlds, while being expandable and robust.
This paper presents our experiences in building a ubiquitous context-aware information system, the SensAid Pad. A component-oriented research system with tools to facilitate the construction of physical information navigation scenarios. It integrates hardware sensors with the notion of context and tokens, together with simple yet powerful graphical user-oriented tools in a prototyping system.

Key words: Ubiquitous computing, mobile computing, context-aware computing, software engineering, information navigation

1 Introduction

In many working environments of today, mobile, ubiquitous information access and manipulation is potentially a revolutionary technology. Information systems in this environment have to be extremely easy to handle to become usable.

The working environment is often a structured setting with many physical objects and locations that have direct relations to the activities taking place, hence the potential of using the work environment as part of the human user interfaces.

This is where we need software systems to bridge the physical and virtual worlds, both development-oriented and user-oriented. We have built the SensAid Pad, a research system for ubiquitous information navigation, with the intent of studying the designs of physical information access scenarios and the requirements these place on software architecture.

In this paper we describe the SensAid system, with focus on the underlying framework we created, containing the token-based context-aware logic used in the prototyping applications. The system implementation consists of components ranging from hardware sensor abstractions to graphical user interfaces.

2 Related Work

Interesting work has been made in the areas that the SensAid Pad touches. Want et al have made studies in how to augment the workplace with RFID tags, and how to connect the physical and virtual worlds in a multi-facetted working environment [2]. iStuff [3] is a a user interface toolkit designed for building ubiquitous interaction environments. The Phigdets project [4] is a framework for creation of tangible user interfaces. [7] is a system that supports hands-free sensor-based information access, where biometrics and other sensors are integrated to support daily work with information. The WebStickers system [10] is a system for directly connecting printed barcode stickers to URL:s.

These are examples of projects working towards and exploring post-desktop computer interaction. The visions of these projects are all similar to ours, where the physical environment is used to support the user in performing computer tasks. While some are powerful tools to design and implement physical user interaction environments, they are still too wide-ranging to rapidly create physical information access scenarios, which is the aim of the SensAid Pad project. We also aim at simplicity to let end-users be able to set up ubiquitous interaction environments. In our linkage method, one or more sensor inputs are mapped to one or more actions, which is a more universal way of connecting physical and virtual entities than the WebStickers approach. This method is also touched on in [8].

3 The SensAid System

The SensAid system is a platform for building and testing physical information navigation scenarios. By augmenting the environment with for instance RFID tags [12], hardware sensors are able to recognize physical entities and the surroundings of the mobile user becomes a rich tool for accessing information. To facilitate the integration of physical entities in the system, we have chosen a token-based approach where every (augmented) item and contextual entity in the physical environment has a virtual representation. Each of these virtual token representations is set to have either a contextual type or an item type.

The three parts of the system is shown in Fig. 1 and each part is described in more detail below.

The SensAid Framework An underlying framework that contains the functionality necessary to create a token-based application with sensors and physical–virtual linkage. The linkage mechanism between physical and informational entities in our system is based on *rules*, mapping one or more *conditions* to one or more *actions*. More specifically, our rules are a combination of boolean value conditions, that when all are rendered true, launches the actions associated with it. The conditions are virtual token representations, that when recognized by a sensor, are set to true. The actions are documents that are viewed and manipulated through their respective desktop application.

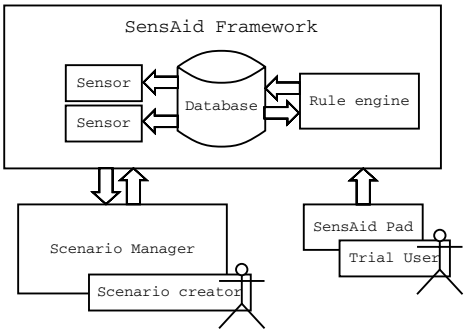

Fig. 1. An overview of the SensAid system.

There are two components using the SensAid Framework, the Scenario Manager application and the SensAid Pad navigation application.

The Scenario Manager The graphical prototyping component, a simple GUI for construction of rules to be used in trial usability scenarios. This is where the links between the physical and virtual objects are produced. By connecting combinations of contextual and item-type tokens to documents in rules in a graphical interface, even non-programmers can set up fairly complex interaction scenarios in a straight-forward manner.

The SensAid Pad The application where the scenarios created in the scenario manager are brought into action, making the pad a information access tool in the physical surroundings. The GUI is virtually non-existent here, which lets the trial user perform purely ubiquitous document navigation.

The *SensAid Framework* is a collection of instruments (type definitions, interfaces, database) to be used in building applications that handles ubiquitous information access using physical entities. The implementation is made in C# and the Microsoft .NET framework [11], using the event system to a large extent for inter-component communication.

One major requirement of the system is to abstract the sensor hardware, therefore each hardware sensor has a wrapper class implemented as an abstraction of the low-level sensor logic. The wrapper contains the code necessary to communicate with the hardware and the ability to identify a token. The token recognizing is performed via calls to the database, where the sensor–token connections are stored. By letting the sensors communicate with the rest of the system using token representation ID:s, we abstract the sensor used to recognize the token, thereby accomplishing a universal usage of sensors.

To accomodate context-aware logic, the application using the SensAidFramework instantiates the `RuleEngine` class with a `Context` object, belonging to the application. The context object contains information on current user and current location, together with events connected to the change of these properties.

Fig. 2. The SensAid Pad in the hands of a user.

This automates the launching of behaviour connected to contextual changes, i.e. updating of rules to trigger actions.

3.1 Reference Implementation

The Scenario Manager and the SensAid Pad usability trial application is intented to run on a sensor-equipped portable computer. In our reference implementation, we use a Nec Versa tablet PC equipped with an RFID reader, to recognize RFID tag-augmented entities in the ubiquitous environment. We also use the microphone built in to the tablet PC together with a simple speaker-recognizing algorithm to identify users. The microphone sensor is activated through a hardware button on the tablet PC. This setup, as shown in Fig. 2, aligns well with Mark Weisers notion of the "Pad" [1]. The sensor setup allows us to recognize any type of token in the environment using the RFID technology, as well as study the integration of multiple sensor by using the microphone.

4 Conclusion

We have described the underlying ideas and implementation of the SensAid Pad system, a system built from scratch for prototyping and testing physical information navigation scenarios for ubiquitous computing environments. The system realizes our ideas of linking the physical and virtual worlds when exploring post-desktop computer interaction.

Describing the environment as tokens in the software system allows us to easily deploy rules that trigger actions for the user. This method makes the system easy to enhance with more sensors, tokens and actions. The rule-based approach has also proved to be a possible way of combining contextual entities such as location with physical items such as paper documents to achieve user tasks on a computer.

The SensAid Pad, although powerful in its simplicity, is limited in some aspects. The rule-based approach might not be the best solution in designing large

ubiquitous environments, since relations among rules becomes hard to comprehend. Also, a more general API for the underlying system is preffered over our current implementation, and is a possible continuation of the project.

5 Acknowledgements

This project has been sponsored by Microsoft Research with a Innovation Excellence Award for Embedded Systems.

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