Creating Pervasive Services with Self-organizable Universal Boards

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Abstract. This paper proposes a novel way that allows users to create pervasive computing environments without experts. In this way, non-smart components which form everyday objects such as furniture and appliances commonly found in homes and offices are made smart in advance, not in the way to convert non-smart objects to smart ones by attaching computers, sensors, and devices. As our first prototype to realize this method, we have developed u-Texture, a self-organizable universal board that enables to change its own behavior autonomously through recognition of its location, its inclination, and surrounding environment by assembling them physically.

1 Introduction

In pervasive computing environment, computers, sensors, devices, and networks are embedded in or attached to non-smart objects and connected for creating context-aware pervasive services. Recently, many non-smart objects are converted into smart objects by various approaches, and a large number of smart spaces, smart rooms, smart furniture, etc., are realized and they support human activities [3]. However, it is difficult for users who are unfamiliar with computing technology, especially, pervasive computing technology, to create and maintain pervasive computing environments without experts. Moreover, most of these environments are handmade by users and the cost and time for building such an environment is a barrier to the development of appropriate pervasive services. To solve this problem, our vision is to establish technologies which enable to create a pervasive computing environment easily without experts. With these technologies, anyone can create the environments anytime and anywhere, and obtain context-aware pervasive applications. As one of our approaches to establish these technologies, we have been developing non-smart objects' components as smart ones in advance, not in the way to convert existing non-smart objects to smart objects. In the case of past researches for realizing pervasive computing environments, objects such as tables, shelves, and drawers in homes and offices are not originally smart, namely most of them are enhanced their functions by attaching computers, sensors, and devices [1, 2]. On the contrary, our approach aims to enlarge functions by making components, such as boards, legs, and props of tables and shelves, smart in advance. As users assemble objects with those smart components, which are beforehand made to have functions to recognize the surroundings and to realize the pervasive computing environments, those components alter their functions autonomously according to the shapes of how they are assembled, and then, objects work as smart objects.

With this approach, it will make possible for a user to realize the pervasive computing environment easily by assembling components physically, without knowledge of each computer, sensors, and devices or setting up them. Because they are getting smaller and cheaper day by day, it is considered as possible to pre-install them in most of the components in the future. In this paper, we introduce a u-Texture which is a prototype made as a smart component beforehand and has been developed for the purpose of realizing the above approach. The u-Texture is a self-organizable universal board, and assembling u-Textures realize smart objects corresponding to the assembled shapes.

In the process to develop a prototype of the first smart components, we focused on the "board shape" which is the basic to form most furniture such as tables and shelves. Because we have regarded that, by assembling furniture with those smartlized components, each smart component would work accordingly to the assembled shape. As a result of that, each furniture turns into and works as a smart object. Several smart furniture realized by the same u-Textures and their availabilities are also introduced.

2 u-Texture

Fig. 1 shows an appearance of u-Texture and examples of several smart objects assembled with them. Basic three actions of u-Texture to be functional as a smart object are given as follows.

Recognition. As a user assembles u-Textures, those assembled u-Textures share information such as whether connected or not, directions of connection, IDs of adjoining u-Textures, and inclinations of themselves. With that information, each u-Texture recognizes its assembled shape and location on the assembled shape.

Adaptation. Available applications corresponding to the recognized smart object will be selected automatically among different applications pre-installed in each u-Texture. A user's input determines one application when there are several choices.

Cooperation. Once an application to be worked is determined, each u-Texture behaves autonomously and works together according to the smart object shape, and each location and inclination.

Fig. 1. u-Texture connects with other ones horizontally and vertically, and collaborates with each other by exchanging location and inclination information, commands, and data.

3 Example Applications

We have developed some example applications to identify the potential of u-Texture. The followings are several kinds of these applications which are shown in Fig. 1.

Smart Table enables to exchange data of each u-Texture on its screen. It can be created by connecting u-Textures and setting it horizontally. When several u-Textures are connected, an arrow will indicate the direction of the other connected u-Texture on screens of each u-Texture. The data will be copied to the u-Texture connected to the direction of the arrow by dragging it to the arrow.

Smart Multi Display enables to display data from a u-Texture widely in cooperation with the connected u-Textures. It can be created by connecting u-Textures and setting it vertically. In the case of connecting u-Textures equally in length and breadth like two times two or three times three, a magnified picture of one designated u-Texture will be displayed. In other cases, longer length takes priority to be output of its magnified picture and un-showed parts also can be scrolled by dragging the picture.

Smart Shelf is a shelf that recognizes what is put on itself. It can be created by assembling u-Textures vertically and horizontally. Putting objects with RF-tag on the shelf, it takes cognizance of the object and records it as a data. With the action, a user can confirm its detailed information by output from the display of the shelf and also search via a network where the object has been put on.

4 System Architecture

The prototype of u-Texture is 320 mm square, 48 mm thick, and 4300 g, approximately the size and shape of a pizza box. u-Texture consists of the following devices with basic computer devices such as processor and hard disk drive. First of all, on the purpose of recognizing a shape of smart object, it has serial port interfaces on its four sides to confirm if it is connected or not, and also accelerometers to find its inclination. And there are wired LAN interfaces on each four sides to exchange data between adjacent u-Textures. It is implemented with a touch panel display as an input device for direct input by users and a fifteen inch display and a speaker as output devices. Common props are adopted for props to be necessary to assemble smart objects such as smart shelf and smart wide displays, installed with wired LAN and serial line for data exchanges between u-Textures at each side, and also implemented with connectors for joining u-Textures. Moreover, u-Texture is built in with an infrared sensor to recognize near u-Textures, and a wireless LAN interface, and a RF-ID reader to exchange data with surrounding environment. As for software, the same and unique middleware are working on all the u-Textures, and they exchange data regarding connections and inclinations explained in the second section and also deal with processing for cooperation among connected u-Textures. Regarding a database, this prototype has been developed to store same database on each u-Texture in advance, and it is possible to update the database through a wireless LAN and to access to the database on the network by each u-Texture.

5 Conclusions

We proposed a novel way that aims to enlarge functions by making non-smart objects' components smart in advance for creating pervasive computing environments easily. u-Texture enables to change its own behavior autonomously by recognizing its location, it inclination, and surrounding environment. Our proposed way contributes to widespread many kinds of pervasive services rapidly.

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