u-Texture: A Self-Organizable Material with Multiple Sensors

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ABSTRACT
We present a new form material called "u-Texture" to assemble Smart Furniture and provide services for human life support, *smartness*. u-Texture is a board-shaped smart material that has abilities to calculate, communicate with each other, recognize its orientation and surrounding environment, output sounds and output animations. Users can assemble u-Textures into various forms of Smart Furniture according to their needs, such as walls, tables, cubes and shelves. The Smart Furniture provides various services corresponding to its composition. Thus, Smart Furniture changes our ordinary space into smartly furnished space instantly. We describe the prototype of u-Texture and ideas of applications, and further will be presented at the interactive posters session in this conference.

Keywords
u-Texture, Smart Furniture, self-organizable, constructible, reconfigurable, various sensors

INTRODUCTION
This paper presents a board-shaped smart material called u-Texture that allows users to assemble various forms of Smart Furniture [5]. In this research, we are focusing on a board-shape, which is basic shape to form most furniture such as walls, tables, desks, shelves and chairs. The concept of u-Texture and Smart Furniture assembled with u-Textures is shown in Figure 1. The main idea of u-Texture is to provide various services dynamically, corresponding to their composition. u-Texture has abilities to calculate, communicate with each other, output sounds, display animations, recognize its form and surrounding environment with various embedded sensors such as an accelerometer for sensing the acceleration due to gravity, a RF tag reader for receiving RF-ID, an IrDA and RS-232 serial for recognizing other near/connected u-Textures.

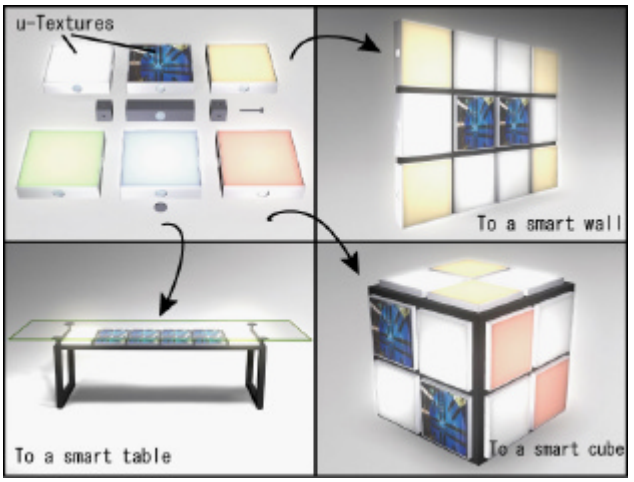

Figure 1. Concepts of u-Texture and Smart Furniture assembled with u-Textures

SYSTEM ARCHITECTURE
We have developed a prototype of u-Texture. It is 38cm-square, approximately the size and shape of a pizza box. Various devices are embedded in each u-Texture to support self composition recognition and to provide services. u-Texture has the following features:

- Advantech POD-6704 Single Board Computer which has four 10/100BASE-T Ethernet ports.
- 10/100BASE-T Ethernet ports and IEEE802.11a wireless Ethernet card. Wired Ethernet is used for communication with other u-Textures connected. Wireless communication is used for connecting to the internet and separated u-Textures.
- Analog Devices ADXL202 2-axis MEMS accelerometer. This senses the acceleration due to gravity, and so can be used to determine evenness and verticality of u-Texture.
- RS-232. This senses whether the adjoining u-Texture is connected or not. If u-Texture is connected, they exchange their IDs.
- Infra-red (IR) LEDs. u-Texture sends a signal with its own ID through IR LED to notify the u-Textures closely around it.

- Radio Frequency (RF) tag reader (13.56 MHz). This senses RF tags attached to objects. The range of detection is within about 15cm.
- 15-inches LCD monitor with KEYTEC, INC. MT-1500-USB. Add-on touch screen kit.

APPLICATIONS

An example of applications of u-Texture is explaining along with a scenario which is shown in Figure 2. In a classroom, each "Smart Table" consists of a single u-Texture unit as shown in Figure 2A. During the class, the Smart Tables work as receivers to obtain contents from the teacher's smart table or the "Smart Blackboard". When a discussion begins, students connect their Smart Tables with each other as shown in Figure 2B. The Smart Tables work as a shared collaborative space for students' opinions and ideas. Smart Tables display the statements the students have made and currently shared data in each discussion group. After the class is over, u-Textures are fit into the wall of the classroom, and start to act as a "Smart Bulletin Board".

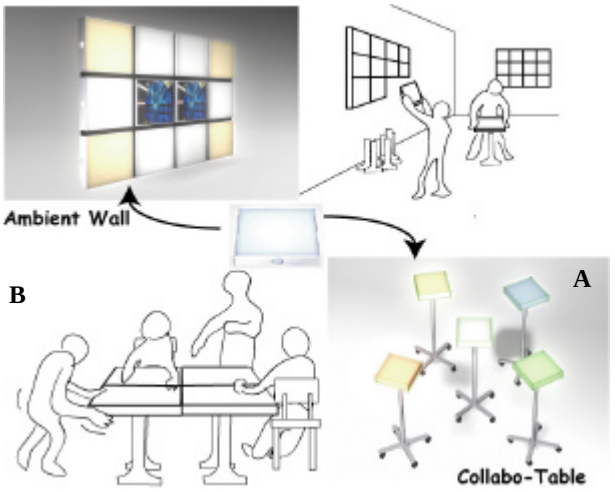

Figure 2. Example use of u-Textures.

RELATED WORK

Although there have been done a number of researches on improvement of smart space by embedded sensors and computers. Only a few of them dealt with alternations of services corresponding to its combination. Smart Furniture [4] and Roomware [2] convert a non-smart space into a smart space where provides location-based context-aware services, service roaming, and personalized services instantaneously with computer augmented things in rooms like lamps, message boards, walls, tables, and others.

On the other hand, not to be things in rooms, there are hints to change a service according to combinations and locations. Triangle [1] is a physical computer interface in the form of a construction kit of identical, flat, plastic triangles. It allows users to be connected together both physically and digitally with magnetic. When pieces contact one another, specific connections can trigger various services. Data Tiles [3] is a tagged transparent tile which integrates the benefits of both graphical and physical interfaces. It can be used as modular building blocks for computational expression with compositions of multiple tiles.

CONCLUSIONS AND FUTURE WORK

In this paper, we have introduced u-Texture, a board-shaped smart material. The major advantage of u-Texture is changing services dynamically by recognizing its composition and surrounding environment. And one major goal is to support human activities by providing services using like a Smart Table, Smart Blackboard and Smart Bulletin Board. The prototype of u-Texture has been developed and those applications have also been implemented. With these smart materials, users can assemble u-Textures into various form of Smart Furniture according to their needs. Our research is still an early phase, and we are considering several research issues and possible future directions as follow;

- Improve recognition of its own composition
- Develop effective middleware to support dynamic service switching, specially how to manage its structure, behaviors and data
- Reduce management cost; build a framework which can install/uninstall sensors easily.
- Improve location detection function of u-Texture
- Collect environmental information around u-Texture to change its behavior, not only by reassembling

ACKNOWLEDGMENTS

This work has been conducted in Ubila Project by Ministry of Public Management, Home Affairs, Posts and Telecommunications, and we thank Team uService.

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BIOGRAPHY

Yuki Matsukura is a student researcher in the UbiLab at Keio University. His interest is geographical information. In this research, His challenge is handling location information in narrow area with collaborating devices.