S-ROOM: REAL-TIME CONTENT CREATION ABOUT THE PHYSICAL WORLD USING SENSOR NETWORK

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Abstract

Project s-room aims to construct a system that permits us to extract object properties and status information and to create content on the Web about physical events by using sensor nodes attached to various objects. This note for the s-room video introduces the concept, basic technologies, and applications developed by s-room research.

1. INTRODUCTION

1.1. Concept

Our world is filled with objects and events. Even in today's information society, we still have not completely converted these objects and events into information. In fact, we can access information for only a tiny portion of them. If we could make visible — in real time on the Web — all the objects and events that surround us, and convert the acquired data into language, anyone would be able to access the information and the useful ideas proposed. When this level is attained, total harmonization of people and objects may open up a completely new world. Providing real-time content that mirrors "the real world as it is" — this is the main goal of the s-room. This note for the s-room video presents the s-room approach, its basic technologies, and applications that have been developed during s-room research. Project s-room provides web content about physical objects and events or open APIs which everyone can access. This strategy may lead us to many applications that are quite different from that of context-aware services.

1.2. Approach

S-room constructs a system for comprehending events, object properties and status information by utilizing sensor nodes attached to various objects. The premise and fundamental technology of the s-room involves monitoring objects and events in sensor networked environments via sensor nodes to obtain an understanding of them. That is, (1) s-room observes physical phenomena that emerge when an event related to physical objects occurs, (2) s-room converts the observed sensor data into words that denote the event, and (3) s-room creates Web content about the event using the event occurrence time. Finding a way to convert data obtained via this fundamental technology efficiently and effectively into words and content in a format that people can easily understand and use is at the core of s-room research.

Project s-room begins with a world in which physical objects have general-purpose sensor nodes equipped with

a) sensors such as an accelerometer, a thermometer, a hygrometer, or an illuminometer, which are expected to become smaller and cheaper;
b) a processor and memory for computation;

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c) a wireless communication module that transmits sensor data to data servers through a network.

It also develops a new type of sensors that enable us to detect a relationship between physical objects.

2. BASIC TECHNOLOGIES

Project s-room has already developed knowledge representation and several basic technologies. This section introduces two of them: Tag and Think and NeighborSense.

2.1 Tag and Think

The system framework, *Tag and Think*, permits us to introduce ubiquitous environments easily and simply by attaching sensor nodes to physical objects without any information about the objects [1]. In the framework, we developed a method that uses real-world knowledge constructed from a person's general knowledge to infer types of physical indoor objects and their states automatically from sensor data produced by the sensor nodes.

The method infers the type and state changes of an object by detecting 'the ways in which the object is used' and by comparing them with the object models. We divide object types into three categories according to their characteristics.

C1: Such object types as toothbrushes and shoes that are moved repetitively.
C2: Such object types as doors and chairs whose characteristics are represented by a combination of characteristic sensor outputs.
C3: Such object types as tables and rulers that have no characteristic motion or whose characteristic phenomena cannot be detected by generic sensors.

We build the models of C2 objects based on a person's basic knowledge and infer object types in C2 using that knowledge.

In Tag and Think, after collecting sensor data from a general-purpose sensor node that has been attached to a physical object for a certain period of time, the method determines the presumed model of the object type from prepared models that matches the sensor data.

2.2 NeighborSense

A general sensor node is equipped with such sensors as an accelerometer or an illuminometer that can detect the motion of the object to which the general sensor is attached or the illumination around it. They cannot, however, determine the relationship between the object and other objects. NeighborSense [2] is a system that permits us to detect the physical contact relationship between objects. An implementation of neighborSense that we have developed is a thin plate with an induction coil formed in concentric circles. Two neighborSense plates detect whether or not they are in contact with by using extremely short distance communication using electromagnetic induction. We have developed plane- and cube-type neighborSense prototypes.

3. APPLICATIONS

Project s-room has developed several applications using the knowledge representation and the basic technologies described in section 2. This section describes two of them. They are object-participation-type weblog, and eventCapture.

3.1 Object-participation type weblog

As an application of Tag and Think, we have developed an *object-participation-type weblog*, where indoor objects with sensor nodes post weblog entries and comments about what happened to them in a sensor networked environment [3].

We implemented a sensor network system in an office. To enable people to continue working, we included desks, chairs, and bookshelves and installed many kinds of objects such as PCs. We installed four video cameras on the ceiling to record the room. We attached sensor nodes to various items of furniture including doors, chairs, tables, cups, an alarm clock, books, locker doors, a drawer, and resealable pouches of tea leaves.

The indoor objects are personified and post weblog entries and comments about what has happened to them. They post entries (1) periodically or (2) when events occur. We can classify these events into three types:
(2-a) weblog posting by users,
(2-b) weblog posting by other objects, and
(2-c) the occurrence of specific events experienced by the objects themselves.

We prepared a total of 34 kinds of services (postings). Some representative examples are:

Door
- If a door is shut loudly many times at midnight, the door issues cautions. (2-c)
- If the times when a door are used is different from usual, the door cautions the user. (2-c)

Chair
- When a user posts an entry about his/her tiredness, a chair posts the total amount of times during which the user sat on it as a comment to the entry. (2-a)
- A chair posts the total amount of times during nervous shaking of the user's leg every week. (1)

Cup
- If a cup is dropped, the cup asks with concern whether or not it is broken (2-a)

Locker and drawer
- A locker and a drawer infer what objects are in them and post object lists every week. (1).

Resealable pouch of tea leaves
- When a user posts an entry about a lost pouch, the pouch infers its location and posts it. (2-b)

Fig. 1 shows a weblog entry that denotes the dropping of a cup. It includes an animation GIF which was recorded when the cup was dropped. We detect the fact that the cup was dropped by finding an acceleration data segment where the values of its three axes are approximately zero.

Fig. 1 also shows a weblog entry posted by a user that denotes a lost tea pouch and a comment posted by the pouch.

The comment includes the estimated location of the pouch and an animation GIF that was recorded when the pouch was last moved before the entry was posted. We infer objects in lockers and drawers by using luminance co-occurrence. When a locker is opened, luminance around the objects in the locker increases.

3.2 Event Capture

EventCapture [4] is a real-time application that searches for, monitors, and visualizes events. It also has a simple event prediction function. By using neighborSense, eventCapture can detect such events as those represented by the verb "put," which eventGo! is unable to detect accurately. It monitors events in real-time and displays 3D movies of these events. EventCapture enables us to predict future events probabilistically just after an event has occurred. This is accomplished by using saved sensor data.

We will be able to construct a broadcast movie site, similar to YouTube, where physical objects equipped with sensor nodes post the movies of events related to the objects by using the 3D movie generation function of eventCapture.

Figure 1. Snapshots of the object-participation-type weblog.

4. SUMMARY

This note introduces the concept, basic technologies, and applications developed by s-room research.

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