Chapter 6
Incremental Knowledge Construction for Real-World Event Understanding

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ABSTRACT

The construction of real-world knowledge is required if we are to understand real-world events that occur in a networked sensor environment. Since it is difficult to select suitable 'events' for recognition in a sensor environment a priori, we propose an incremental model for constructing real-world knowledge. Labeling is the central plank of the proposed model because the model simultaneously improves both the ontology of real-world events and the implementation of a sensor system based on a manually labeled event corpus. A labeling tool is developed in accordance with the model and is evaluated in a practical labeling experiment.

INTRODUCTION

Once a computing environment becomes capable of understanding real-world events, it will be able to provide services in response to a given situation. In addition, users will be able to exchange and share real-world situations. The former application is well known as context aware services and the latter has recently been called environment-generated media (Maekawa, 2007). These applications observe the real world by using sensors, detect real-world changes as events and then drive various kinds of services according to the events occurring in the environment.

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If the objectives of services and their environment are clearly defined, it is possible to determine the kind of information that the services require and also how to obtain them depending on the problems to be solved. For example, the e-Nightingale project (Noma et al., 2004) is targeting event recording related to medical nursing and to this end they developed a small wireless accelerometer.

In contrast, when activities of daily life are targeted, a problem arises, namely the difficulty of defining target events a priori. This requires the construction of knowledge about real-world events. In this field, Philipose (2004) and Wyatt (2005) extracted 26 activities of daily life and made it possible for them to be recognized by attaching RF-ID tags to the objects in the environment and having participants wear RF-ID readers on their hands. Perkowitz (2004) aggregated knowledge about activities and related objects and then recognized the activities from the sequences in which the objects were used.

In addition to RF-ID tags, we assume that small wireless sensor nodes containing, for example, accelerometers, magnetic compasses, and illuminometers will be attached to objects in the environment. Various events will be detected by these sensor nodes, and they will then provide various services. However, the problem of defining appropriate events will become more difficult.

In this article, we describe an incremental method for constructing an event ontology, namely the knowledge needed to understand real-world events, on the assumption that such sensor nodes are attached to various objects in the environment. Although the method mainly targets knowledge construction, it also simultaneously targets the development of a sensor networked environment. The method focuses on *labeling*, that is, constructing an event corpus in which the observed sensor data streams are annotated manually by human operators with reference to the event ontology being constructed. In the proposed method, the event ontology, event corpus and implementation of the sensor environment are incrementally constructed during the iterative labeling process.

This article is structured as follows. We first propose a knowledge construction model. We then discuss the elements of the proposed model, and introduce a labeling tool developed in accordance with the model. We finally describe the result of a practical labeling experiment conducted in a developing sensor networked environment.

EVENT DETECTION IN SENSOR NETWORKED ENVIRONMENT

Obtaining Real-World Events

What kind of real-world events should be obtained from a sensor networked environment? When we focus on activities of daily life, we can find both human movement in the environment and changes in the status of objects, which are observed as independent events by multiple sensors. However, the observed events must be mutually related.

As an example of a daily event, assume that a person turns a light on. From the perspective of describing human activities, the event can be described as "(someone) turned the light on." In terms of describing changes in the status of a device, the status of the light changed from "off" to "on." As regards describing detected changes in the outputs of sensors attached other objects in the room, the event would be described as "the illuminometer output increased." Thus, the description of an event varies depending on the perspective. These differences arise from the way in which sensors are distributed and how they detect changes in the environment.

Returning to the example of "turning a light on", there are several ways to detect a real-world event. The simplest and most certain approach is to focus on the status of the light, and this can be detected by observing its electricity consumption. When focusing on human activities instead, a