Real-world Event Recognition using Multiple Instant Learning Sensors

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***Abstract*—This paper discusses meta-event recognition methods using multiple smart sensors. We previously proposed a smart sensor, which is implemented on small and low-cost microcontroller device, and can instantly learn and detect sound events. We consider an aggregation method for multiple event information to improve recognition rate and estimate position of sound source, reasoning relations among detected events. Using collaborated smart sensors, developer will easily build smart objects and smart spaces utilizing real world sounds without signal processing programming.**

I. Introduction

Recent researches in activity recognition show that signal analysis with sensors like microphones and accelerometers are useful in building rich ubicomp environment. However, it is not easy for people who are not signal processing experts to design and implement recognition algorithms.

In our project, we aim at realizing smart sensor modules for non-signal processing experts to utilize rich context information from sound and acceleration. We previously focused on "Sound" in our daily-life, and proposed an Instant Learning Sound Sensor [1], which has micro-DSP chip and uses piezoelectric-device as microphone. This inexpensive device can instantly learn event signal patterns, locally process signal analysis and be used as a simple event notifier with other systems. By using the smart sound sensor, many real world events can be recognized without signal processing programming.

In this paper, we introduce meta-event recognition methods to extend kinds of recognizable event in real world. Proposed smart sensor only outputs information whether the target event sounds are detected or not. However, we think combination of these multiple event information can reason higher-level event information. This meta-event contains information about relationships among some events, for instance, concurrency, dependency and sequence. Furthermore, by differences of amplitude levels that are detected in each sensor, they will be able to estimate positions of event sources. These combinations will provide more useful context-awareness and activity-awareness. For example, if "sound of falling rain" and "sound of rotating a door knob" are simultaneously detected, then user's smart phone may suggest taking an umbrella. Of course, because of "smart sensors", a user doesn't need signal processing programming.

II. Collaboration for Mulitiple Smart Sensors

We think four types of aggregation methods.

(1) Scaling up number of target events: We designed and implemented our sensor device as simply a few sounds recognizer with Microchip dsPIC, which has only 8KB RAM. By using several sensors, user can make them recognize several events simultaneously.

(2) Improving recognition rate: Current smart sound sensor can recognize various events with almost over 80% accuracy, but in some case, it can't do well [1]. The recognition rate may be improved by majority decision with multiple sensors that senses same event. It is can serve as fault-tolerant.

(3) Reasoning relationship among events: To recognize concurrency, we use a neural network. Inputs are a set of similarities of pattern matching results of each sensor. Output layer is a detection result of mete-event (0 or 1). A developer can also assign actions in output layer, for example appliance control services. In learning, all a developer has to do is only to prepare teaching signals, like Programming by Example.

(4) Estimation of position of sound source: Using two or more sound sensors, a position of detected event is estimated by model that is based on ratio of sound's amplitude level of pair of sensors and distance between sensor and event source. The reason we use ratios in model is every event may have different powers, and it is difficult to use absolute value. Then, our method calculates existing probability of each position by using that model.

Fig.1 shows (2) improving recognition rate with three sensors and (4) estimation of position of event with two sensors. By using proposed methods, a user can easily integrate these meta-event recognitions into user's ubicomp application.

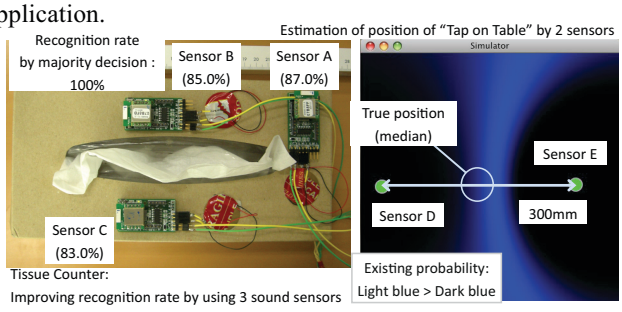

Fig 1. Example of improving recognition rate and estimation of position

[1] Yuya Negishi, Nobuo Kawaguchi, "Instant Learning Sound Sensor: Flexible Real-World Event Recognition System for Ubiquitous Computing", UCS2007, pp.72--85, Nov. 2007