Indoor-Outdoor Activity Recognition by a Smartphone

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ABSTRACT
It is increasingly important to recognize daily activity pattern in order to detect early sign of dementia in the aging society. This paper shows indoor-outdoor activity recognition using only a smartphone. We developed an indoor living activity recognition engine and an outdoor migration activity recognition engine, and combined them into an Android™ application. The former recognizes not only "resting" or "walking" but also user's various living activities such as "vacuuming" and "brushing teeth" by using a built-in accelerometer and a built-in microphone. The latter engine recognizes the user's means of migration, namely, "resting," "walking," "running," and "boarding" by using a built-in accelerometer. It enables users to continuously recognize indoor-outdoor activities by switching between the two engines depending on an acquisition condition of GPS.

Author Keywords
Activity Recognition, Smartphone, Accelerometer, Microphone, GPS

INTRODUCTION
Activity recognition has been a hot topic in the field of ubiquitous computing research for years along with the popularization of easy-to-use accelerometers and sensor-equipped mobile devices such as mobile phones and smartphones. Various living activities have become recognizable by wearing accelerometers on several parts of the body [1], or wearing a dedicated device on the wrist [2]. Although activity recognition by commonly used devices has an advantage over the above-mentioned studies in terms of practicality, it is difficult to recognize various indoor living activities. We think it would be ideal for context-aware services to continuously recognize both indoor and outdoor activities by using a general-purpose device.

SYSTEM OVERVIEW
We propose an indoor-outdoor activity recognition system to recognize various activities in real time by using a smartphone as shown in Figure 1. We developed an indoor living activity recognition engine (Figure 2) and an outdoor migration activity recognition engine (Figure 3), and combined them into an Android™ application. By switching between the two engines depending on an acquisition condition of GPS satellites, the system enables users to continuously recognize indoor-outdoor activities. Moreover, we also developed a transmitting function to a cloud server or an external terminal via 3G networks or Bluetooth™ in anticipation of various practical services.

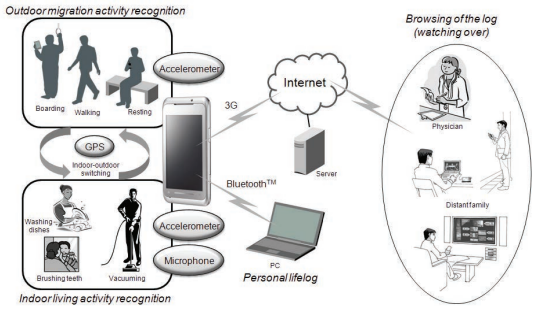

Figure 1. System Overview.

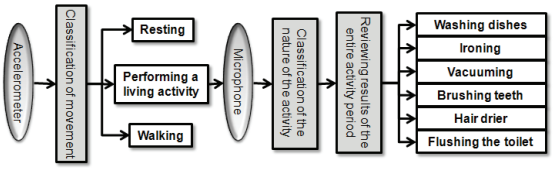

Figure 2. Flow of Indoor Living Activity Recognition.

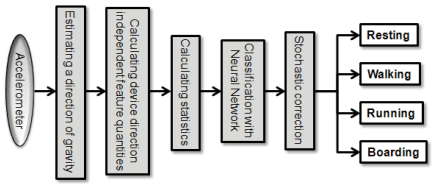

Figure 3. Flow of Outdoor Migration Activity Recognition.

EVALUATIONS
We confirmed that the proposed system had a practical performance through an evaluation experiment with 21 subjects (6 men and 6 women in their 60s, and 5 men and 4 women in their 20s to 40s). Indoor movement classification had more than 95% accuracy and the classification accuracy of 6 indoor living activities was about 85% on average. Outdoor migration activities were classified with more than 90% accuracy on average.

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