WINFO+: EXTRACTING ENVIRONMENTAL INFORMATION USING WALKING SIGNALS

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Abstract

With the advent of wireless sensor nodes, we can create a system of environment monitoring in urban areas. Although variable sensors can be deployed densely in a certain area, it is not cost effective to use sensors more than necessary. Instead of embedded sensors, we can utilize information emitted from walking people. Based on the idea, we propose a system to extract environmental information by sensing "human body." In our system, we have extended WINFO, a previously developed system for broadcasting personal sensed information, to analyze people's walking conditions from heart rate and pressure signals at the people's feet. In this paper, we describe an architecture and demonstration of WINFO+.

1. Introduction

Recent advances in MEMS (Micro-Electro-Mechanical Systems) technology have enabled the development of relatively low-cost and low-power wireless sensors. Such sensors can be used for various monitoring applications [1]. Although variable sensors have been deployed in a wide area, we consider that there still exists hidden information which is extracted from how people actually feel/sense in the area. Besides the advances in these environmental monitoring technologies using wireless sensor networks, we have seen rapid progress of body sensor networks such as elderly people's fall detection, exercise condition, and personal healthcare. However, such sensed data from a person are mainly used for knowing the condition of the individual. Based on these backgrounds, we propose a system to extract environmental information by sensing human body. In our system, we have extended Wearable micro-INFOrmation broadcaster (WINFO) [2]. We call the extended system WINFO+. In WINFO, we aggregate emitted data from a person and map the information as a distributed map. We set three goals in WINFO: device scalability, information scalability, and resource scalability. Device scalability means client devices can acquire the amount of information depending on their screen size and CPU power. A device with richer resources will present finer information on its display. Information scalability is dealing with the dynamic behavior of data. If the data has a large change either in temporal or spatial axes, the granularity of the data should be small. Finally, resource scalability determines the frequency of sensing and transmission depending on the available remaining battery. To enhance the scalability, we also consider data compression for sensed data. In WINFO, a client obtains information about the state of raining by analyzing data

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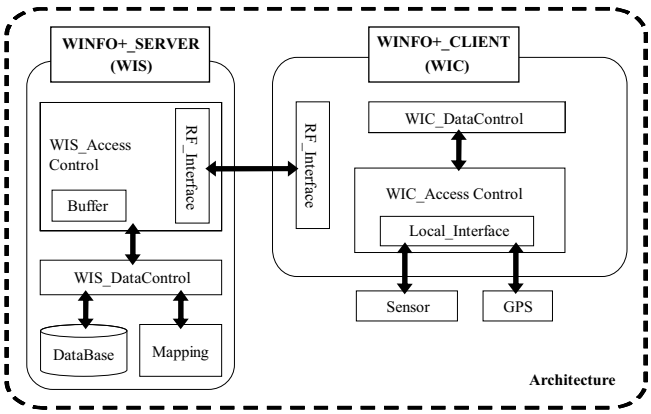

Figure 1. Architecture of WINFO+

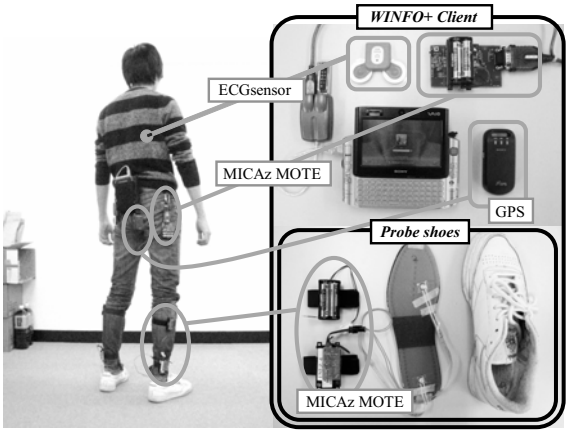

Figure 2. Installation of WIC

from a sensor on his/her umbrella. However, to extract hidden information (especially in an urban area), we consider that a key is how to analyze data from various sensors on their *body*. Therefore, in WINFO+, we consider a person as *HumanProbe* and propose more sophisticated method for identification of environmental condition by analyzing heart rate and pressure signals at the people's feet. The rest of the paper is organized as follows. Section 2 describes the architecture and implementation of WINFO+. Sections 3 and 4 describe our demonstration and related works, respectively.

2. WINFO+ Architecture and Prototype Implementation

In this section, we describe the architecture of WINFO+. The WINFO+ system is based on a client-server model and composed of WINFO+ client (WIC) and WINFO+ server (WIS) as shown in Fig. 1.

2.1. WINFO+ Client (WIC)

WIC is a device attached to a person. It consists of a laptop computer, probe shoes, ECG (electrocardiogram) sensor, GPS (Global Positioning System), and wireless interface. The prototype system is shown in Fig. 2. Because shoes are used for not only walking but also probing, we call them probe shoes. We installed pressure sensors at the forefront and the rear of the probe shoes. The ECG sensor is attached at user's chest. The laptop computer obtains the raw data of pressure values and heart rate from both sensors. The data is tagged with timestamp obtained the GPS and transferred to WIC_DataControl. In the WIC_DataControl, the raw data is maintained in tuple composed of summarized data of walking, heart rate, latitude, longitude, and timestamp. The tuple is transmitted to WIS through the wireless interface.

2.2. WINFO+ Server (WIS)

WIS receives tuples of data from multiple WICs and stores the tuples into a Database. The Database is connected to Mapping module through WIS_DataControl. Upon receiving a request for data in a certain area from a WIC, the WIS returns the corresponding data.

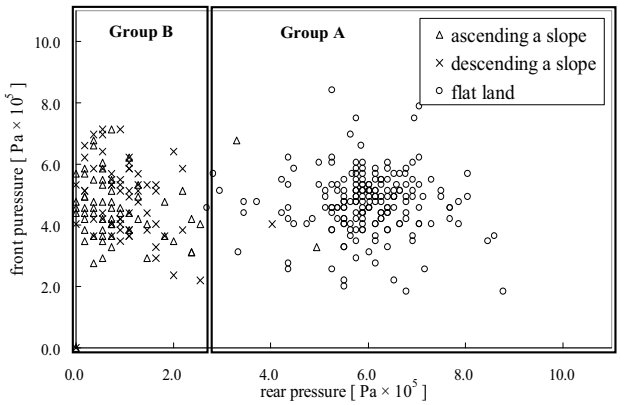

Figure 3. Front-rear diagram

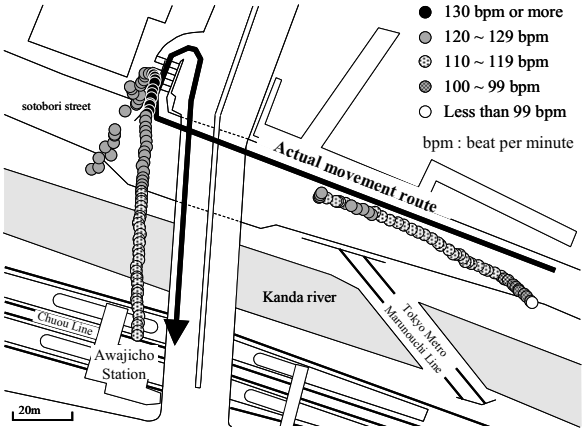

Figure 4. Map obtained from mapping phase

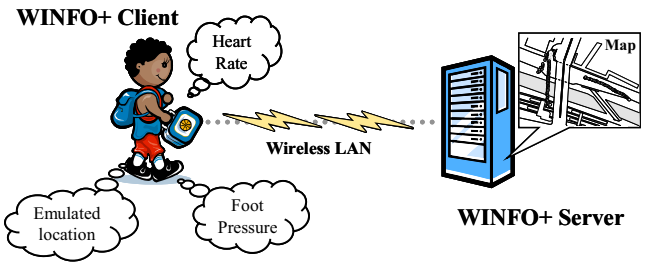

Figure 5. Overview of our demonstration

2.3 Mapping Module

Pressure data and heart rate in the Database is analyzed by WIS_DataControl in order to identify environmental condition. The Mapping module creates a map of environmental information from the analyzed environmental condition and the location information obtained from WIS_DataControl.

2.4 Analysis of Walking

Our approach focuses on the transition of peak values of pressure. Let us define an epoch as a period of contacting a floor. We extract the peak values of the forefront and the rear during the same epoch. Fig. 3 shows classification based on a set of the peak values of forefront and rear pressure. In Fig.3 we can observe that walking at a flat area and at a slope is distinguishable by plotting data onto a two-dimensional plane. As a result, we acquire environmental information (flat land or slope) from walking signals.

3. Demonstration

In the current WINFO+ system, we associate a set of a person's heart rate, foot pressure, and location with a map in the outdoor environment. In fact, we have taken several data in downtown Tokyo. However, at the Pervasive demonstration, it may be difficult to show an experiment for the outdoor environment. Therefore, we use the emulated location information for the demonstration.

In the Pervasive demonstration, WIC is installed onto a user's body and the user moves inside a room. While the person is walking, a type of walking is identified based on the distribution of foot pressure. At the same time, the person's heart rate is obtained and they are bound with the pre-

determined pseudo location. Finally the combined information is displayed on a map. The obtained map will be presented as shown in Figure 4. Figure 5 shows overview of our demonstaration.

4. Related Work

Our system is considred as one of embodiment of Human Probe. In the same context, people-centric urban sensing [3] and BikeNet [4] have been proposed. In contrast to these systems, we utilize information emitted from human's body. With respect to relating sensed information to a map, work on annotated maps [5] is similar to our system. However, our system utilizes human's information more directly onto a map than the annotated maps.

5. Conclusion

In this paper we have described the concept of aggregated personal information and the basic architecture of WINFO+. A WINFO+ client device obtains a person's walking condition together with the person's location. Thus, the information about easiness of walking is generated if the number of WINFO+ participants increases. Extensive experiments over an outdoor field remain for our future work.

6. References

[1] Ono, T., Ishizuka, H., Ito, K., Ishida, Y., Miyazaki, S, Mihirogi, O., and Tobe, Y., Uscan: Towards fine-grained urban sensing, Proc. of Int'l Workshop on Real Field Identification, 2007.

[2] Sasaki, K., Inoue, U., and Tobe, Y., WINFO: A human-assisted sensor network, Proc. of 2nd Int'l Workshop on Networked Sensing Systems (INSS 2005), 2005.

[3] Campbell, A. T., Eiscnman, S. B., Lane, N. D., Peterson, R. A., People-Centric Urban Sensing, Proc. of the 2nd Int'l Conf. on Wireless Internet, 2006.

[4] Eisenman, S. B., Miluzzo, E., Lane, N. D., Peterson, R. A., Ahn, G-S., Campbell, A. T., The BikeNet Mobile Sensing System for Cyclist Experience Mapping, Proc. of ACM SenSys 2007, 2007.

[5] Riedel, T., Scholl, P., Decker, C., Beigl, M., A Community Platform for Auto-Annotated Receational Maps, Proc. of SWDMNSS 2007, 2007.