Prototyping and Evaluation of a Wireless Sensor Network That Aims Easy Installation

Takanobu Otsuka, Tatsunosuke Tsuboi, and Takayuki Ito

Abstract. The number of senior citizens living alone are increasing in Japan. Accordingly, the budget for social security is increasing. The percentage of burden for social security budgets reached 69.5% only for senior citizens recently, and will increase more and more. These budgets are consumed in mainly in the larger hospitals. Thus, recently "in-house" health care for senior citizens is gathering much attention in Japan. Various "home-care" products are increasingly developed and implemented to care the health of the senior citizens. However, these products are usually expensive and their self installation is very difficult. In this research, we developed a wireless sensor network system that realizes easy installation and easy operation. Our preliminary experiments demonstrate that our system can surely find some anomaly sensing information without any difficult installation procedures.

1 Introduction

The number of senior citizens living alone are increasing in Japan. Accordingly, social security budget is increasing. Even though Japans total population has become stagnant, in 2010 the percentage of senior citizens reached 23.1% and is still increasing. The percentage of burden for social security budgets reached 69.5% by senior citizens. The Japanese government realized that this is a really important budget problem and must need to be tried to be solved. The Japanese government got the medical institutions to decrease the number of beds for senior citizens because of mainly the budget, and switch the policy toward to home health care. Because of

Takanobu Otsuka
School of Engineering, University of California, Irvine, Irvine, California 92697-2625
e-mail: otsuka.takanobu@nitech.ac.jp

Tatsunosuke Tsuboi · Takayuki Ito
Nagoya Institute of Technology, Gokiso, Showa-ku, Nagoya, Aichi, Japan
e-mail: tsuboi.tatsubosuke@itolab.nitech.ac.jp,
ito.takayuki@nitech.ac.jp

M. Ali et al. (Eds.): *Contemporary Challenges & Solutions in Applied AI*, SCI 489, pp. 27–32.
DOI: 10.1007/978-3-319-00651-2_4

the above situation, the importance of home health care is increasing drastically in Japan. Various home care products are developed to provide home health care for senior citizens. The following are the examples of them.

- The alert system that monitors for abnormally wanders by senior citizens
- Life safety alarm system to monitors for an old person living alone
- Emergency call and reporting systems for unusual status
- Emergency telephone calling system for unusual status

However, these products are usually expensive and their installation is difficult. Our research aims to develop a system for easy operation and easy installation. Because we conducted a cooperative research with the Niihama medical Coop as a preliminary test in Japan. In this research, we could identify the problem in which system developer needs to know in the real world. We conducted a research with the cooperation of the Niihama Medical Co-op in Japan. Niihama Medial Co-op was consistently operates a large clinic, a group home, a day care, and a day service. It is a few medical institutions in Japan which gives home health care and medical care throughout. Generally medial institutions are divided medical services and home health care services. Therefore the burden on user is big the Niihama Medical Co-op. was integrating medical and home health care services. The Japanese government got the medical institutions to decrease the number of beds for senior citizens because of mainly the budget, and switch the policy toward to home health care. In this research we aim to realize an easy-install and easy-operation sensor modules for both of the care-provider sides and senior people.

The rest of our paper is organized as follows. Section 2 introduces previous studies and the position of our research. Section 3 presents our prototype system and the configuration of our test demonstration. Finally, Section 4 summarizes our paper and provides future work.

2 Related Works

2.1 General Product Features

The system [1] can simply notify 2 times per day for the senior citizen when they drink a cup of tea. The systems [2]can analyze the behavior patterns using the motion sensors and send some emergency reports.[6][7] The systems [4]have been developed with RFIDs and sensors for analyzing the behavior patterns in order to send the notifications of abnormal events as a whistle-blower system. The systems[3]have the wearable sensors that can monitor temperature by the thermometers. The system [5]can detect abnormal behavior by using a video camera. The following are the problems on the above related works.

- Generally they are expensive products for installation.
- They require the separated communication cables.

- Video cameras will invate privacy too much.
- Werable sensors increase the mental burden of users
- They require huge computational power to process the videos
- Their main purposes are to altert rathern to wantch/see.
- Their visibility of the activity logs is not sophisticated.

3 Development and Test Demonstration of WSNs

3.1 Feature of Zigbee

We selected the most suitable transmission standards because it should be wireless.

The most unique point of Zigbee is that itfs ultra-low power consumption and it can built easily for a mesh type network[8][9]. Specifically, Zigbee-based modules work 6 monthes with only the battery type CR2032. When a communication command is taken out from the unit A to the unit B, it can select a single route from A to B. You can select any route for data coomunication in the mesh network of Zigbee.

The second unique point is the mesh network of Zigbee. Installed Zigbee has a repeater function, so that you can operate as a repeater by setting Zigbee in the middle point in the case of short of communication distance. It is the optimal as a sensor network because you can use these features without special installation. Moreover some Zigbee have a program area alone, you can mount the sensor which easy calculation is attached although rich calculation canft be performed.

3.2 The System Outline

We have developed a sensor network that can be installed easily by anyone. While users can begin to operate by simply putting unit, the sensing result can be viewed on the webpage. This section describes the developed system. An overview of the system is shown in Figure1.

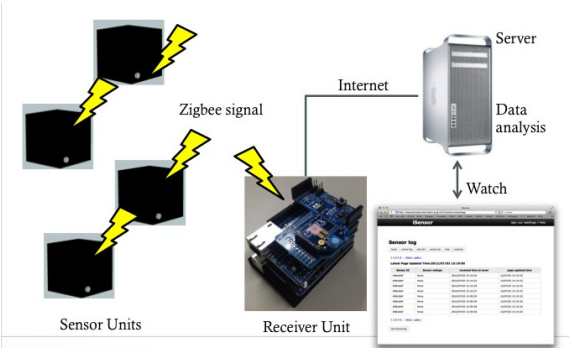

Fig. 1 System outline

Sensed data by the sensor units transmits to the server. The server can display the sensed data in a web page almost realtimely. We developed the sensor unit is running by an internal battery. This is because any power supply cable is not required.

3.3 Experimental Setting

By installing the sensor units for two of our rooms, we have collected the sensed data for performing anomaly detection by sensing the actual data. The sensor unit has been placed in accordance with the flow line of the students.

While Figure 2 shows the room-A layout, Figure 3 shows the room-B layout.

Room-A is divided into two main areas, illustrated the flow line to the path toward the entrance of their desk. Sensors are arranged at right angles to the flow line thereof, because it is about 5m, the entire laboratory sensingis possible. For simplicity, room A is similar to that of a relatively businesses and households.

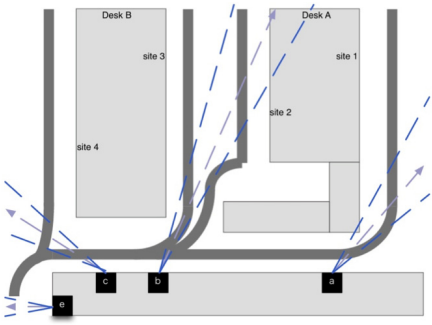

Fig. 2 Room-A layout diagram of the sensor unit

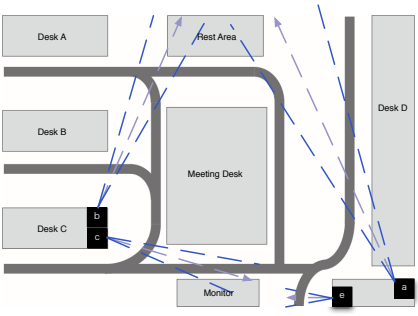

Fig. 3 Room-B layout diagram of the sensor unit

Room-B is a meeting room space in which, there is a desk that is arranged at the center, and the other tables surround it. We assume room-B is a conference room or a free space.

We collected the following data:

- Data collection periodF2012/07/01-2012/08/22
- Number of data collection of room AF242,053
- Number of data collection of room BF177,623

Our outlier detection is performed by clustering the collected data. We divided into four clusters by the k-means method. While the vertical axis as the time, the horizontal axis are date. A data that deviates from clusters can be seen as a anomaly.

3.4 Experimental Result

Experimantal results for room-A and room-B are shown in Figure 4 and Figure 5, respectively. Because there are a lot of people in the room-A compared to room B, while the result on room-A looks more continuous, the result of room-B is more intermittent but looks continuous as well. From both figures, many sequential reactions of sensor e, sensor b and sensor c can be seen in the results because they were installed in a doorway where many people were passing.

In the Figure 4 and Figure 5, some anomaly data can be seen. These anomaly data are actually reactions caused by a heat source by the sunlight. However, what we can confirm is our sensor system can show some anomaly data in the graphs. In the real usecase, analyist can interpret these anomaly data based on the domain.

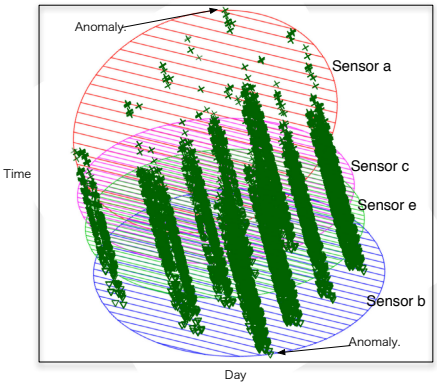

Fig. 4 Clustering result of room A

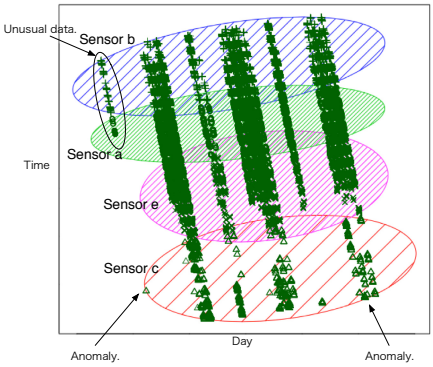

Fig. 5 Clustering result of room B

4 Summary

Recentry, a lot of services that can monitor senior people or detect intruders have been focused very much. But the usual systems are expensive and we need expert knowledge to install them. In this study, we have developed a sensor network that is low cost and easy to installation. In addition, the system also performs the anomaly detection method by clustering. We conducted the experiments with 2 real typical rooms. Then, we showed that our system can classify correctly the normal sensed data and abnormal sensed data. The abnormal sensed data, in this experiment, was a kind of the noise[10]. But it could be an intruder or some other happening. As future works, realization of anomaly detection using bayesian network, it is possible to aims easy installation.

Acknowledgements. This work is partially supported by the Funding Program for Next Generation World-Leading Researchers (NEXT Program) of the Japan Cabinet Office.

References

1. Zoujirushi Corp., Mimamori Hot Line, http://www.mimamori.net/
2. Aoki, S., Onishi, M., Kojima, A., Sugahara, Y., Fukunaga, K.: Recongnition of a Solitude Senior's Behavioral Pattern Using Infrared Detector, The institute of Electronics, Information and Communication Engineers. Technical report No. 2001-50 (2002)
3. Tanaka, H., Nakauchi, Y.: Senior Citizen Monitoring System by Using Ubiquitus Sensors. Society of Mechanical Engineers, Journal No. 75–760 (2009)
4. Furuya, M., Murakami, H., Miyamoto, W.: Detecting of an illness date based on usual activities of the single elderly person by using a few sensors, The institute of Electronics, Information and Communication Engineers, Technical report No. 2002-125 (2003)
5. Seki, H., Hori, Y.: Detection of Abnomal Action Using Image Sequence for Monitoring System of Aged People, The institute of Electronics, Information and Communication Engineers, Jouanal No. 122–2 (2000)
6. Chandola, V., Banerjee, A., Kumar, V.: Anomaly Detection: A Survey. Technical Report, Department of Computer Science and Engineering University of Minnesota, TR-07-017 (2007)
7. Rajasegarar, S., Leckie, C., Palaniswami, M.: Distributed Anomaly Detection in Wireless Sensor Networks. In: 10th IEEE Singapore International Conference on Communication Systems, ICCS (2006)
8. Lennvall, T.: A comparison of WirelessHART and ZigBee for industrial applications. In: Factory Communication Systems, WFCS 2008, May 21-23 (2008)
9. Varchola, M., Drutarovsky, M.: Zigbee Based Home Automation Wireless Sensor Network. Acta Electrotechnica et Informatica 7(4) (2007)
10. Rousseeuw, P.J., Leroy, A.M.: Robust regression and outlier detection. John Wiley and Sons, Inc., New York (1987)