Health Monitoring System in the Bedroom using Ubiquitous Technology

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ABSTRACT
Advances in information technology have enabled ubiquitous health monitoring at home, which is particularly useful for patients, who have to live alone. We have focused on the automatic and unobtrusive measurement of biomedical signals and activities of patients. We have constructed wireless communication networks in order to transfer data. The networks consist of Bluetooth and Wireless Local Area Network (WLAN). In this paper, we present the concept of a ubiquitous-Bedroom (u-Bedroom) which is a part of a ubiquitous-House (u-House) and we present our systems for ubiquitous health monitoring.

INTRODUCTION
Ubiquitous health monitoring allows biomedical signals to be measured without the individual's awareness. For successful ubiquitous monitoring the biomedical signals need to be measured unobtrusively and the data need to be transferred using a wireless communication system.

Biomedical signal measurement is very important in the field of telemedicine and health monitoring because it is the precursor of analysis and diagnosis. In previous studies unobtrusive biomedical signal measurement was not a main issue. M. Ishijima[1] presented a method to measure Electrocardiogram (ECG) in bed without any body surface electrodes. Instead of body surface electrodes, conductive textile electrodes were used in order to measure ECG signal. T. Tamura et al.[2] showed that it was possible to obtain ECG signal in the bathtub only using water.

Bluetooth communication technology has many advantages for the field of telemedicine. A lot of data has to be transferred and processed because biomedical signals, activities and environmental parameters are always being monitored. Wireless Local Area Network (WLAN) is needed in association with Bluetooth communication network. Using Bluetooth technology and WLAN, any problems regarding bandwidth and speed can be solved.

In this paper, we describe ubiquitous health monitoring system in the bedroom. We have focused on the unobtrusive biomedical signal measurement and wireless data transfer using Bluetooth technology and WLAN. These two main technologies have enabled ubiquitous health monitoring without patient's awareness.

MATERIALS AND METHODS
The ubiquitous-House (u-House) has a toilet, kitchen, living room, and three bedrooms. Sensors are installed in each location. In the bedroom, there are five sensors which measure biomedical signals, activities and environmental parameters.

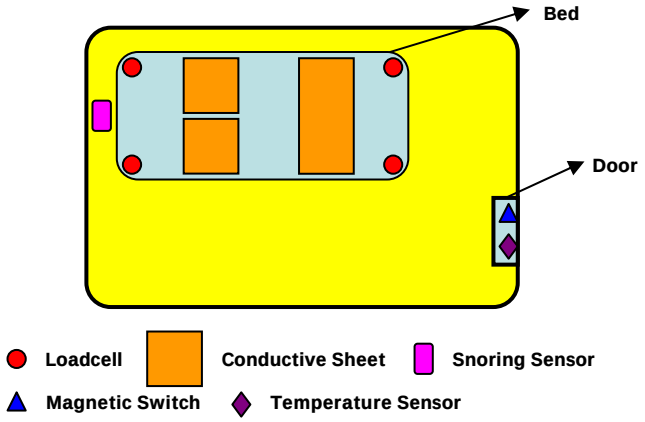

Fig. 1 Diagram of the ubiquitous bedroom and location of sensors

A. Unobtrusive Biomedical Signal Measurement

In the bedroom, three biomedical signals can be measured from the bed.

1) ECG signal measurement on bed

An ECG signal can be obtained from the patient in bed using a conductive sheet. Whenever the patient lies on bed at night, ECG signals are measured by a conductive textile electrode attached to the bed sheet. In order to process the ECG signal an amplifier has been developed. This bio-amplifier has several filters, namely a low-pass, notch, and high-pass filter. Such filters can remove noise and it is possible to obtain a clear ECG signal comparable to the common Ag-AgCl direct contact electrode.

2) Body movement during sleep

During sleep, the patient moves around. The movement of patients can reflect their health. To analyze their health, movement needs to be measured. The four compression type load cells[3] which have been attached to the legs of the bed can measure these movements.

3) Snoring detection during sleep

The number of patients who suffer from severe snoring has been increasing. It is necessary to detect snoring and assess how long he/she snores during sleep. Snoring detection equipment uses an electret condenser microphone and RMS-to-DC converter.

B. Activities and Environmental Parameters Monitoring

Activity monitoring can be beneficial for elderly people who live alone at home. If a medical doctor has ordered a patient to do exercise such as wandering around at home, it is possible to monitor whether he/she does exercise or not. Attaching a magnetic switch to a door makes it easy to find out whether the door has been opened or not.

There are several parameters regarding the environment such as temperature, humidity, noise, and illumination. It is important to monitor these parameters continuously for the patients. It is possible to measure room temperature using a thermistor which is a kind of variable resistor. The resistance of thermistor decreases as the increase of temperature.

C. Networks

The Wireless communication has enabled unobtrusive health monitoring. Lots of wires in the bedroom can annoy patients. A Bluetooth network has been used for the purpose of transferring data from the sensor to the Bluetooth access point[4] and a WLAN has also been used from the Bluetooth server to the Home server. For the WLAN, a Personal Digital Assistant (PDA) has been installed in each bedroom.

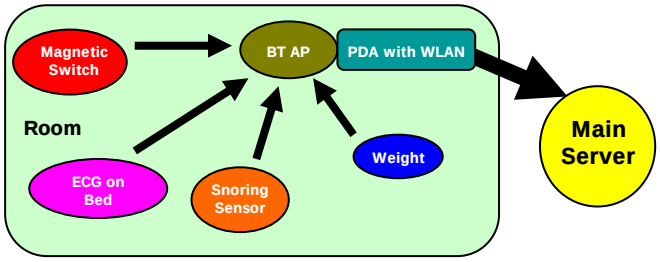

Fig. 2 Diagram of the data transfer

D. Data Processing Unit

For data processing and transfer, a small data processing unit has been developed. It consists of three parts – power, microcontroller and Bluetooth module.

This processing unit can do Analog-Digital Conversion with a 10bit resolution. Analog signals can be digitized and transferred to the Home server which collects and analyzes the data. In our successive studies, this processing and transfer unit will be used and modified.

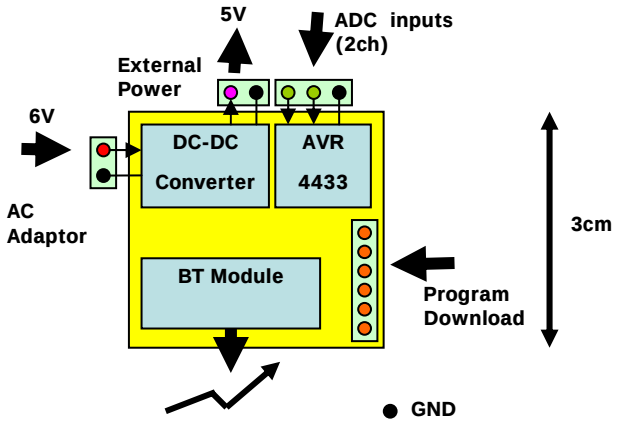

Fig. 3 Diagram of the data processing unit

DISCUSSION AND CONCLUSIONS

There are a lot of sensors which can measure biomedical signals, activities and environmental parameters unobtrusively. Among them, just a few sensors were used in our installation. In the future, other useful sensors will be used in experiments. For body fat measurement, a method which can estimate bio-impedance will be applied. In addition, infrared sensors will be used for movement detection and humidity sensors also will be used for humidity monitoring. Other sensors can be easily incorporated into our system because we have already developed the small-size data processing and transfer unit.
We have not done sufficient experiments on elderly people. In this paper, the experiments should be considered preliminary and more data is needed.
Unobtrusive biomedical signal measurement and data transfer via wireless communication has enabled ubiquitous health monitoring. Just sleeping on bed and walking around the room allows measurement of some biomedical signals. In addition, activities of patients and environmental parameters such as temperature can be recorded without any notice of the patients.

REFERENCES

1. M. Ishijima, Monitoring Electrocardiogram in bed without body surface electrode, IEEE Transactions on Biomedical Engineering, 1993;40(6):593-594
2. T. Tamura, T. Togawa, M. Ogawa, M. Yoda. Fully automated health monitoring system in the home, Medical Engineering and Physics, 1998;20:573-579
3. CAS Co. LTD http://www.cas.co.kr
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The abstract contains the concept of u-House and the methodologies. The poster will describe the results which have been collected in u-Bedroom. Several graphs and tables will be shown in my posters. I introduce some pictures and graphs in this page.

Fig. 1 Conductive textile electrode for measuring ECG in bed

Fig. 2 Load cell for measuring body movement in bed

Fig. 3 Magnetic switch and data processing module

Fig. 4 Data processing unit

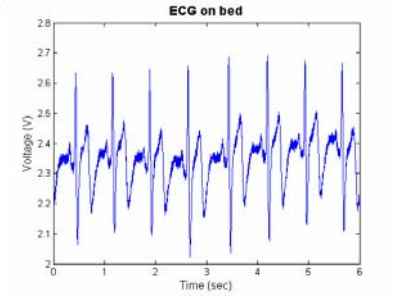
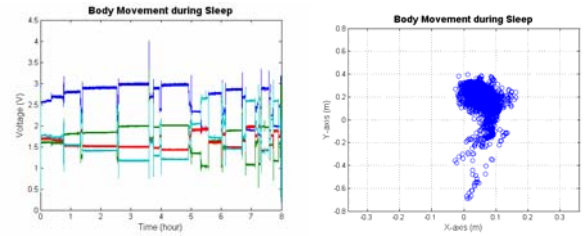


Fig. 5 ECG signal obtained from conductive textile electrodes



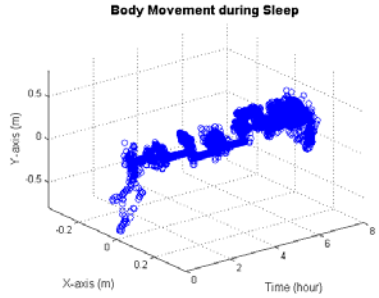


Fig. 6 Body movement data during sleep obtained from 4 load cells

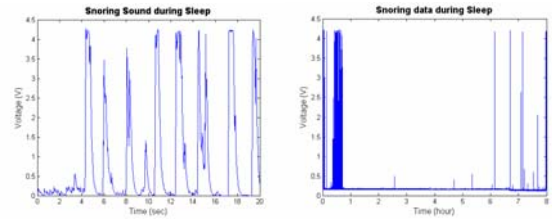


Fig. 7 Snoring during sleep