Advanced Science and Technology Letters
Vol.51 (CES-CUBE 2014), pp.119-123
http://dx.doi.org/10.14257/astl.2014.51.28

Implementation of Fabric-Type Flexible Platform based Complex Bio-signal Monitoring System for Situational Awareness and Accident Prevention in Special Working Environments

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Abstract. This paper was aimed at implementing fabric-type flexible platform based complex bio-signal monitoring system which can acquire and monitor complex bio-signals (heartbeat, body temperature, ECG, and EMG) and additional situational information (3-axis acceleration, temperature, illuminance, humidity, and neighboring image) of special workers employed in special working environments, such as police officers, soldiers, and firefighters, and at introducing the immediate and efficient measures by preventing various accidents in the working environments and recognizing the situations that the workers face.

Keywords: wearable system, flexible platform, complex bio-signal, wireless network

1 Introduction

The highly advanced and rapid development of IT and medical technology resulted in rises in people's interest not only in the health industry, but in the healthcare area aimed at alleviating and curing patients' diseases and in the wellness area aimed at preventing diseases and improving physical strength of healthy people. In convergence of the phenomenon with ubiquitous network, it has advanced into the u-Health area, which, with the help of communication technology, goes beyond hospitals and medical institutes and is being applied to other industrial areas, including home, mobile environment, offices, and special organizations (e.g., the police, the military, fire stations).

This study implemented fabric-type flexible platform based complex bio-signal monitoring system which can acquire and monitor complex bio-signals and situational information of special workers employed in special working environments, such as police officers, soldiers, and firefighters in order to maximize work performance through real-time situational awareness and entailing immediate measures and to lay the foundation for securing the technology of the service applicable to prevent various accidents in the working environments and improve public safety.

ISSN: 2287-1233 ASTL

2 Main body

2.1 Components of the System

The module which is used to acquire bio-signals of the workers employed in special working environments should neither impede their work nor get restricted to a system. Therefore, it is required to design a system reflecting the problem more carefully and delicately. In this study, this researcher took the problem into account and produced attachable/detachable non-restraint flexible PCB using wearable typed fabric electrodes. Fig. 1 presents the whole components of the complex bio-signal monitoring system based fabric-type flexible platform.

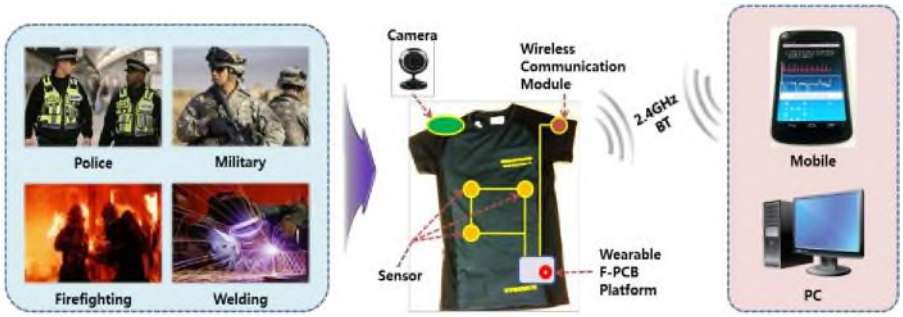

Fig. 1. System components.

The wearable typed flexible platform consists of ECG for monitoring heart activity, EMG for monitoring muscle fatigue, and complex module for providing situational information, such as bio signals like body temperature, postures, work rate, and calorie consumption. Also, it includes the wireless communication module supporting Bluetooth and a separate camera module helping to visually recognize external situations so that all kinds of data including visual data can be sent to an administrator from workers' mobile devices or PCs.

2.2Algorithms for situational awareness and emergency judgment

In this paper, the algorithms using ECG, 3-axis acceleration sensor, body temperature, posture, and other parameters were applied for situational awareness and emergency judgment of workers. For the algorithm using ECG, as shown in Fig. 2, MIT-BIH Arrhythmia Database was used to reflect ECG data in the direction of LDA (Linear Discriminant Analysis), and SVM (Support Vector Machine) algorithm was applied to detect arrhythmia (Sensitivity: 99.75%, Specificity: 99.99%).

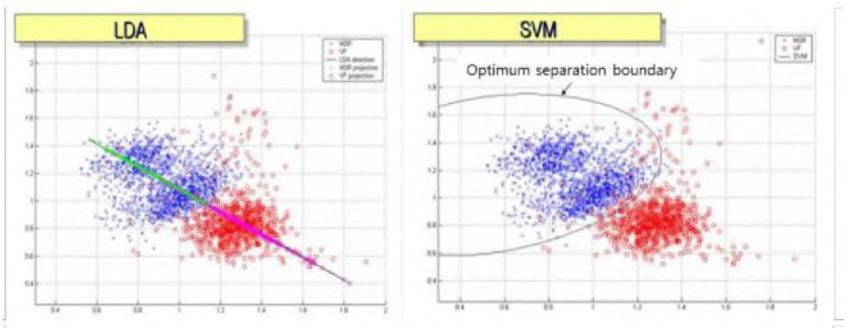

Fig. 2.Arrhythmia detection algorithm using LDA and SVM.

For the algorithm for behavior estimation and posture judgment, the mean, standard deviation, and signal power of the AC signals of 3-axis acceleration signals were used to classify dynamic movement. Fig. 3 illustrates the time-series change for AC signals of 3-axis acceleration signals.

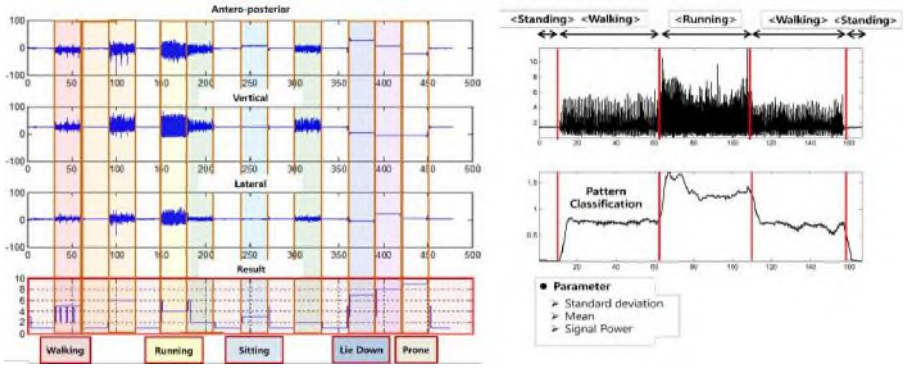

Fig. 3.Poster judgment algorithm by 3-axis acceleration sensor.

2.3 System Implementation

In the case of the module to acquire wearable F-PCB based bio signals, to design a measuring instrument relatively less sensitive to the impedance change between electrodes and skin, the voltage that occurred in common mode was connected with negative feedback circuit to reduce the electrode-skin impedance greatly; to design the integrated system reflecting the electric activity signals of heart and frequency characteristics of muscle fatigue, the frequency domain of electric heart activity was 0.01~66Hz, and that of muscle fatigue was 5~480Hz. Fig. 4 illustrates the implemented F-PCB based flexible platform.

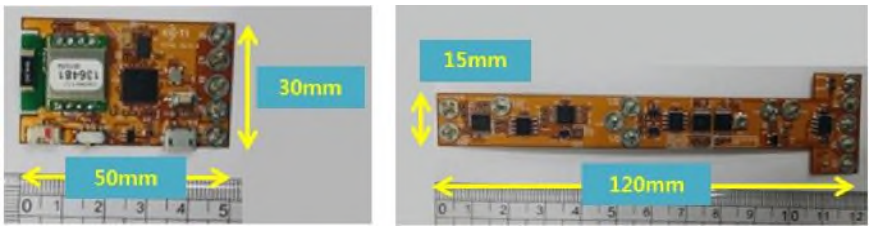

Fig. 4.F-PCB based wireless communication module and bio-signal detection module.

The bio-signal monitoring software was designed to collect various bio signals from wearing workers and monitor them. The data being received is divided into wave data and numeric data, each of which is temporarily saved into the data structure for bio-signal data management and storage and is later either displayed or saved and sent in database. The interface comprises wave viewer and numeric viewer to make it easy to analyze and classify bio signals. It reflected bio-signal parameters necessary to be monitored. Aside from that, it includes Alert Set up Menu for emergency, Setting Bar for entering users' information and setting serial ports, and Communication Setup Popup Menu for data storage and wireless transmission with the central monitoring system. Fig. 5 illustrates the architecture of bio-signal monitoring software.

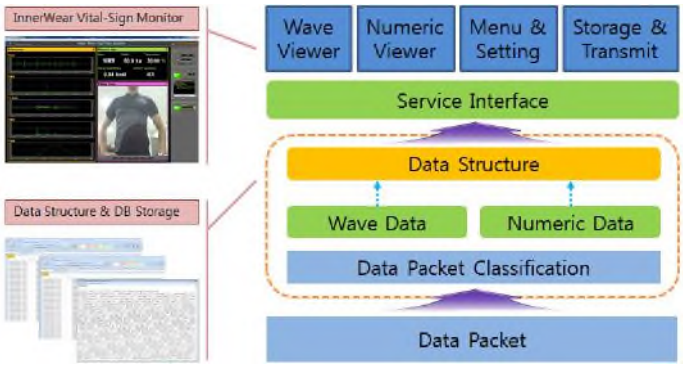

Fig. 5. Architecture of bio-signal monitoring software.

The bio-signal monitoring software structuralizes data to remotely gather and monitor the collected bio signals and sends them to the central monitoring system. Therefore, the ISO/IEEE 11073 based module to transmit bio signals was developed, and packets and communication protocol were designed.

3 Conclusion

This study developed fabric-type flexible platform based complex bio-signal monitoring system which can recognize in real time the situations of workers employed in special working environments and take immediate measures to maximize work performance, and prevent various accidents in the their working environments.

To do that, it produced the flexible PCB attachable and detachable to wearable typed fabric electrodes to design complex bio-signal detection module, and developed and applied the algorithms used for situational awareness and emergency judgment on the basis of the acquired complex bio signals and additional situational information. In addition, the developed system used the wireless communication method supporting Bluetooth to guarantee workers' non-restrict characteristics, applied ISO/IEEE 11073 protocol for transmission of bio signals to support the future expansion with the central monitoring system and smooth connection with application layered services.

This research and development is expected to lay the foundation for securing the technology to provide a wide range of services going beyond the u-Healthcare area which is currently limited to hospitals and clinical institutes.

Acknowledge. This work was supported by the IT R&D program of MSIP/KEIT. [14-000-11-001, Human Friendly Devices (Skin Patch, Multi-modal Surface) and Device Social Framework Technology]

References

1. Lim, C. Y., Jeon, K. M., Ko, K. C., Koh, K. N., Kim, K. H.: A Study on the Estimation of Energy Expenditure and Falls Measurement System for the Elderly. Journal of The Korea Society of Computer and Information, vol.17-4, pp.1--9 (2012)
2. Lin, C. W., Ling, Z. H., Chang, Y. C., Kuo, C.J.: Compressed-domain Fall Incident Detection for Intelligent Homecare. The Journal of VLSI Signal Processing, vol.49-3, pp.393--408 (2007)
3. Zhang, T., Wang, J., Xu, L., Liu, P.: Fall Detection by Wearable Sensor and One-Class SVM Algorithm. LectureNotes in Control and Information Sciences, pp.858--863(2006)
4. Maddison, R.: Estimating Energy Expenditure with the RT3 Triaxial Accelerometer.Research Quarterly for Exercise and Sport, vol.80-2, pp.249--256(2009)
5. Marinos, D., Leonidas, F., Vlissidis, N., Giova-nis, C., Pagiatakis, G., Aidinis, C., Vassilopoulos, C., Pistner, T., Schmitt, N., Klaue, J.: Medical and Safety Monitoring System over an In-Cabin Optical Wireless Network. Taylor & Francis Journals, International Journal of Electronics 98(2), pp.223--233 (2011)

