A Study of Significant data Classification between EDR extracted and frequency analysis of Heart Rate Variability from ECG using Conductive textile

Yeon Sik Noh[1], Sung Bin Park[1], Kyu Seok Hong[1], Young Ro Yoon[1] and Hyoung Ro Yoon[1]

[1] Biomedical Engineering, Yonsei University, Wonju, Republic of Korea

Abstract— **The aim of this study is classification of correlative data through comparison between ECG-Derived Respiration (EDR) and High Frequency (HF) component obtained frequency analysis of heart rate variability (HRV) from ECG using two of conductive textiles. Generally, individual frequency range of the HF component has been determined only by means of distinctive parameters of respiration such as respiratory rate, range and median value of respiratory rate, etc. However, in many cases Low Frequency (LF) components and High Frequency (HF) components may be superimposed on each other totally or particularly and can not be diagnostically estimated because respiratory rhythms are individually much remarkably differentiated. This study, in consequence, analyze frequency component of EDR derived from ECG and then compare with high frequency components of HRV and finally find out valuable data for further analysis. Hardware constitution is used to bed type ECG measurement equipment based on U-Healthcare, can identify user using Radio Frequency (RF) module as well as manage data each of user. We used Frequency Modulation (FM) method based on Respiration Sinus Arrhythmia (RSA) in order to extract EDR from ECG signal. ECG data and EDR data were processed with LabVIEW, then classified through each of frequency analysis.**

Keywords—**Heart Rate Variability, ECG-derived Respiration, Conductive textile**

I. Introduction

Recently, the average span of Korean life has been taken a new lease by elevation of GNP, improvement of quality of life, advancement of medical science, etc, and Korean society can be said to become an aging society. As a result of this, concern has been expressed about the quality of medical care that elderly residents receive in residential and nursing homes [1]. We consider this concern as a easily solvable problem by adding the concept of "Ubiquitous". The stream of electronic healthcare system has moved up ubiquitous healthcare system such as personal home networking healthcare in the digital consumer electronics, which system enables medical professionals to remotely make real-time monitoring, early diagnosis, and treatment for potential risky disease, and to provide the medical diagnosis and consulting results to the patient via wired/wireless communication channels [2]. The most important features of ubiquitous healthcare system are unconsciousness and noninvasiveness. Therefore, Devices for telemedicine, more exactly, remote monitoring of physiological or daily living signs should be reflected with these considerations as follows; 1) no pain or burden must be imposed to acquire information on health condition, and 2) no restriction of living condition must be added either. Another consideration should be given for extraction of qualified data as not only sites where measuring achieved are individual residences, but also operators who control the system are ordinary persons.

As a part of constructing ubiquitous healthcare system in our research, we have built testbed for simulating general outcome. This testbed is composed of 3 sections, bedroom, living-room, and lavatory. In this study, We focus bedroom section where electrocardiography (ECG) and ECG-Derived Respiration (EDR) signals are acquired continuously from the bed.

The objective of this study is to find out significant heart rate variability HRV signal through comparison between power spectrums of EDR and R-R interval variability ratio. It is reported that results obtained from examinations with standardized psychic load in which ECG and respiratory signal are continuously recorded and adequately processed have shown that the true individual frequency range of the HF component can be reliably determined only by means of characteristics of respiration (respiration rate; RR, range and median value of RR, tidal depth), and respiratory rhythms are inter-individually extremely differentiated and of individual-specific nature. In many cases LF and HF components may be totally superimposed on each other and consequently cannot be diagnostically evaluated [3].

Accordingly, the aim of this study is to automatically put precious data compared among data acquired to practice use. To accomplish this, we made hardware and software constitution as below.

Hardware constitution basically includes bed type ECG measurement equipment based on ubiquitous healthcare. There are two electrodes of conductive textile on bed. It can obtain EDR through a connected process using data acquired from two electrodes. As well, using RF module can identify user who he/she is. After confirming user, ECG

signal acquired and EDR derived can be transmitted to main computer via Bluetooth equipment.

Software constitution includes a process that compares power spectrum between HRV from RR intervals and RRV (Respiratory Rate Variability) from EDR signal.

II. Methodology

It is transmitted host computer of ubiquitous system through Bluetooth node that ECG signal acquired from two electrodes, EDR and user identification information together. It starts comparison for finding out significant data among data that complete transmission. R-R interval signal and EDR is reorganized same time series, and DC offset voltage is removed by de-trend curve.

A. Hardware

Fig. 1 The scenery of data acquisition. Two electrodes are located on the pillow and the calf of legs.

Hardware is made up of two portions. One part is a process of acquisition of ECG data from two conductive textile electrodes and EDR data which is extracted from ECG signal. Another part is process of identifying a user using RF module and transmit ECG and EDR signal to a host computer. The scenery of data acquisition in bed shows in figure 1. First, it is part of data acquisition. It detects R peak and EDR signal using FM method based on RSA through ECG signal corresponded to Lead III from subject's neck and leg surroundings. Although it is underestimated EDR using two lead than using one lead [4][5], EDR using one lead can be better as some subjects [6] because lead subordinate relationship has different phase by individual respiration pattern, location of heart, rotation degree of heart, and low orthogonal degree between Lead III and Lead I[7]. Generally, for removing baseline of ECG acquired, it is a fastest method that uses result of difference between raw signal and signal after applying high-pass filter (HPF), but we use median filter for removing baseline because HPF may lead to gross distortion of QRS complexes and possibility that it can be changed ECG modulation information by respiration. QRS complex detection use threshold method based on differentiation, which was developed by Pan and Tompkins [8]. It determined QRS area applying same that window in R peak found. R-R interval is difference between time of the present R peak and R peak coming next. ECG amplifiers, generally, protect human being with RL-drive circuit; make low voltage of common mode input voltage. In this study, as ECG amplifier using only two electrodes, it could not make a RL-drive. Therefore, It is necessary to make ECG amplifier with high common mode rejection ratio because it is used that each electrode which made up conductive textile (pillow electrode size: 103cm × 50cm, leg electrode size: 149cm × 41cm) is bigger than normal standard electrode. First, we assume that two electrodes and RL electrode are connected as impedance combination model. That output passes resister-capacitor connection of RL-drive, and then it enter two electrodes again. It makes low value of common mode input voltage. Incomplete common mode input voltage is sampled by multiple of this signal, removed by moving average filter in micro-controller (MSP430F149, Texas Instruments). Bluetooth model we used is Korwin Corporation's product using BTM2711CO of Samsung Electronics Corporation. Transmission part of Bluetooth is connected with RS232, transmit ECG data, R peak detection data, R-R interval data, and EDR data to host computer by 300Hz sampling frequency. Second, RF module model is Nano-24 of Octacomm Corporation. Because they have unique identification value each user respectively, a system identify user when user come near RF module. Then host computer compare data and store each user respectively by data included ID information.

B. Software

In this paper, it is used LabVIEW 7.1 version of National Instruments for all Signal processing. Software over all consists of data re-composition, reorganizing same time series, removing DC offset voltage, and user interface part.

First, part of data re-composition treats only R peak detection data and EDR data among transmitted data from micro-controller. We uses ECG signal in order to clinical interpretation from HRV signal, it consists of long-term

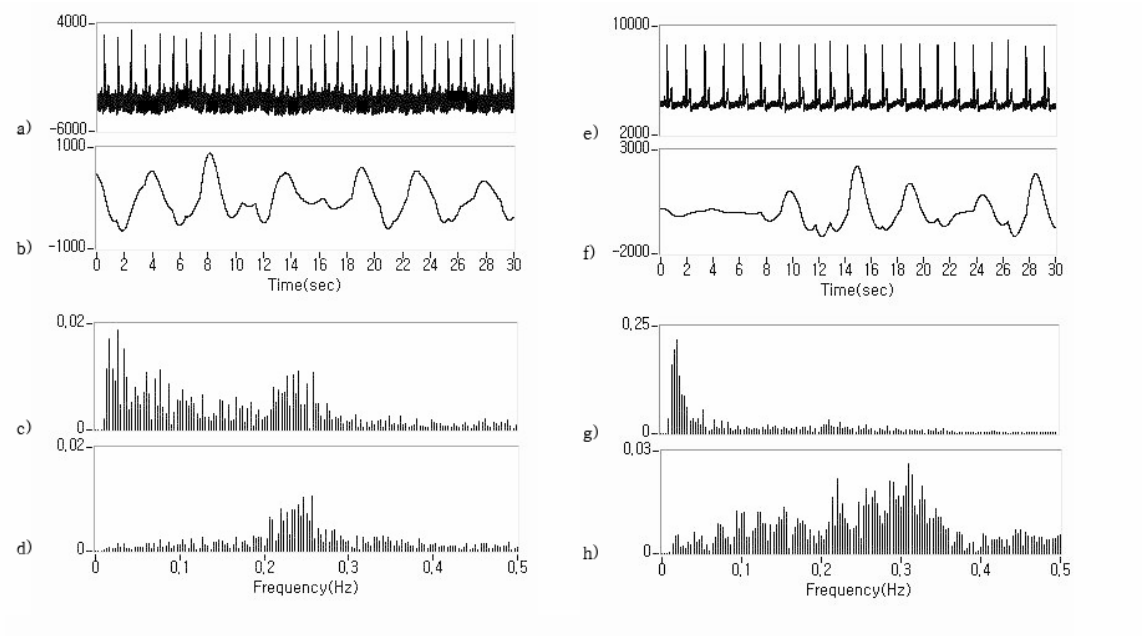

Fig. 2 Raw data and power spectrum analysis of high correlative data and low correlative data before classification

a) ECG signal of high correlative raw data
b) EDR signal of high correlative raw data
c) Power spectrum analysis of high correlative HRV signal
d) Power spectrum analysis of high correlative EDR signal
e) ECG signal of low correlative data
f) EDR signal of low correlative data
g) Power spectrum analysis of low correlative data
h) Power spectrum analysis of low correlative data

analysis using 24 hours data and short-term analysis using 5 minutes data by measured time. In short-term analysis, if you do not control subject's condition and measurement environment, it can misinterpret of diagnosis because it reflect instantaneous physiological variance. But it is impossible that use long-term analysis because we can not obtain 24 hours data in this study. We, however, can obtain clinical variable data using short-term analysis because we can control measurement environments. One is that data acquisition accomplishes during sleeping at bed, another is that we can minimize error through interpolation method. Whole data during sleeping time is automatically divided in 1 hour interval, and then 1 hour data divided is divided in 5 minutes interval again. It prepares to start data analysis.

Second part are reorganizing data same time series and removing DC offset voltage from data. Raw data from micro-controller is transmitted data sampled by 300Hz, the wave of R peak detection has figure like impulse series. Heartbeat rate of human being, mainly, maintain in regular interval, but actually time of detecting R peak does not have a precise period. We, therefore, need re-sampling data about a certain time in order to analyze in frequency domain. We use Re-sampling method of Waggener. This algorithm is designed for analyzing respiration signal originally. We can draw the wave about R peak detection time of ECG signal and interval values at that R-R interval. We recompose wave that have precise period through down sampling in 5Hz about varying R-R interval values and R peak detecting time. Finally, we must remove DC component of wave reorganized in same time series, it is possible by difference between wave reorganized and its 4th de-trend curve. If it passes former processes, we get the power spectrum signal of both HRV and EDR respectively. Each of power spectrums of data analyzed during 5 minutes is tested their cross-correlation. If this value is bigger than 0.5, the signal at that time is stored hard disc. If not, that signal is deleted because it is not significant data. As well as cross-correlation value, if it do not have any energy from 0.15Hz to 0.4Hz, it also deleted by same reason. Using the significant data rested, it calculates cross-correlation values during 5 minutes data, 1 hour data, and whole data of user.

The final part is user interface portion. User can automatically confirm cross-correlation analysis of significant data by only once click mouse button, also can confirm power spectrum wave of each of 5 minutes interval and each of hour interval using LabVIEW.

III. Result

Ten subjects participated in this paper. We controlled measurement environment for minimizing error of short-term analysis. We acquired data through more than 6 hours in sleep condition at bed. Basically, analysis executed all sleeping time, and the results are shown at table 1. Each hour of values are cross correlation values about continuous middle hours except first 1 hour and right side values are cross correlation values about all the time. We disregarded LF component but interested in only HF component because Power spectrum of respiration signal by RSA have range from 0.15Hz to 0.4Hz [9]. If energy of HF component are out of range and cross correlation is lower than 0.5, that data is automatically remove. Figure 2 is shown that raw data and power spectrum analysis of high correlative data and low correlative data before classification. The classification of set of significant data is confirmed as worthy data because cross correlation results are mostly bigger than 0.7. Through this study, we show possibility of significant data acquisition during sleeping as well as active time.

Table 1 Result of correlation between HRV and EDR signal

X: Power spectrum of HRV signal
Y: Power spectrum of EDR signal

Subjects	Each hour of XY correlation				XY correlation of whole data
	1st	2nd	3rd	4th	
A	0.71	0.78	0.79	0.75	0.76
B	0.71	0.78	0.76	0.88	0.78
C	0.74	0.71	0.79	0.73	0.74
D	0.66	0.69	0.67	0.51	0.61
E	0.65	0.63	0.66	0.73	0.67
F	0.74	0.74	0.87	0.74	0.77
G	0.80	0.80	0.87	0.84	0.83
H	0.77	0.72	0.62	0.70	0.70
I	0.81	0.78	0.79	0.76	0.79
J	0.79	0.80	0.79	0.90	0.82

IV. Conclusion

Likewise other parts, biosignal measurement have also an effect on Ubiquitous. It demands that measurement of bio signal is performed in free and unconscious condition at comfortable place like home. Classification about only signification data at bed type measurement equipment based on U-Healthcare is not finished certification, but spread out other fields related respiration signal.

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Address of the corresponding author:

Author: Yeon-Sik Noh
Institute: Biomedical Engineering, Yonsei University
Street: 234 Maeji, Heungup
City: Wonju
Country: Republic of Korea
Email: mninys@bme.yonsei.ac.kr