긴급환자 상황인식 및 분석을 위한 무선 ECG모니터링 시스템

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A Wireless ECG monitoring System for Application in Life Emergency Event Detection and Analysis

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요 약

헬스케어와 무선 기술의 접목은 새로운 생체신호 모니터링 방법과 환자의 이동성 및 편의성을 제공하며 더 나은 방법으로 환자를 돌볼 수 있으며 이러한 장점으로 인해 최근 무선기술을 이용한 ECG 모니터링 및 계측 시스템이 개발되고 있다. 본 논문에서는 중요한 생체신호 중 가장 중요한 신호의 하나인 ECG 신호를 무선센서네트워크를 이용하여 무선으로 받은 후, 이를 서버컴퓨터에서 의사, 간호사 또는 환자의 보호자에게 진단의 기초자료로 제공할수있게 빈맥, 서맥, 동정지와 같은 비정상적인 ECG신호를 판단하는 ECG 모니터링 시스템을 구현하였다. 신체에서 계측된 ECG신호는 무선으로 서버와 RS-232로 연결된 베이스스테이션으로 전송되고 서버는 비정상적인 ECG 신호를 검사하여 저장 및 모니터링을 위해 PC/PDA로 데이터를 전송하며, 이러한 시스템을 활용하여 의료비 절감 및 더 편리한 의료서비스를 받을 수 있을 것으로 예상된다.

ABSTRACT

An ubiquitous healthcare system for the home care of elderly persons was designed and implemented using wireless sensor network technology. The wireless technology for home-care purpose gives new possibilities for monitoring of vital parameter with wearable biomedical sensors, and will give the patient the freedom to be mobile and still be under continuously monitoring and thereby to better quality of patient care. Emphasis is placed on recent advances in wireless ECG system for cardiac event monitoring with particular attention to arrhythmia detection in patient. This paper presents a diagnostic system for cardiac arrhythmias from ECG data, using wireless sensor technology. The system also provides an application for recording activities, events and potentially important medical symptoms. The hardware allows data to be transmitted wirelessly from on-body sensor to the base station and then to PC/PDA. Data is also transmitted to a back-end server for analysis using wireless internet connection. Experiments were conducted using the system for activity monitoring, exercise monitoring and medical screening tests and present preliminary data and results.

Keyword
ECG, monitoring, wireless sensor network, abnormal

I. INTRODUCTION

Outfitting every patient or elderly person with tiny wearable wireless sensors and registering their vital signs allows continuous health monitoring by doctor, nurses, other care-givers and the patient themselves both in the hospital and home environment. Several ongoing international researches like Body Area Network(BAN) are focusing on improving the patient's ability to freely move around in a daily situation while being monitored by a wearable system[1]. We are trying to develop a robust platform for real-time monitoring of patients in their home transmitting data to doctors working at the hospital[1,4].

Our system for a wireless, continuous event recorder for ECG-signals lyes from base station to server. The sensor includes three electrodes applied directly to the patient's body which are directly connected to electronic circuits for amplifying the signal. The wireless transmission of the sampled data to a receiver integrated as a component within a PC/PDA. The ECG is continuously recorded with a built-in automatic alarm detection system, for giving early alarm signals even if the patient is unconscious or unaware of cardiac arrhythmias[2]. The doctor at the hospital uses a special remote client installed on a standard PC as a Clinical Diagnostic Station(CDS). Trained personnel will thus be able to evaluate the ECG-recording for diagnosing the conditions detected and follow up the patient accordingly[3]. Doctor can set the actual alarm limit; for bradycardia, tachycardia, and arrhythmia according as variations in R-R intervals. If an abnormal ECG activity is encounter, the Server will store 1 minute of the ECG-recording and then give alarm to doctor's PDA. In addition the Server will calculate Heart Rate(HR) and variation in the R-R interval, averaged values together with maximum and minimum values every one minute. We have used Pan-Tompkins real time QRS detection algorithm[6] for calculation of Heart Rate and variation in the R-R interval. The doctor can have a long-term ECG database, he/she can analyze the signal statically and can diagnosis an emergency condition. Fig. 1 shows the architecture of ECG monitoring system. It is possible to make an easier and more cost efficient ambulatory ECG recording compared to existing solutions on the market, and patient can be continuously monitored in his home-situation doing daily activities.

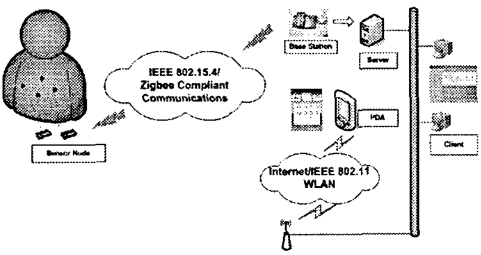

Figure1: Architecture of ECG monitoring System

II. SYSTEM DESIGN

The sensor measures ECG-signals with a sampling frequency of 200 Hz. The signal is digitalized with 10 bit resolution, and continuously transmitted to a receiver-module attached to PC/PDA, with the use of a modulated RF-radio link where we use the RF-transmitter CC2420(chipcon Inc., Norway). The sensors are sticky and attached to the patient's chest. It will continuously measure and wirelessly transmit sampled ECG-recordings by the use of a built-in-RF-radio transmitter to the base station and then to PC/PDA with a RS-232 connector[1][2]. After saving the serial data received from the base station, ECG data is analyzed, which includes searching the R-peak and finding the beat rate, in real time. Server/Client software programs were developed in C# based on .Net compiler for monitoring and analyzing the ECG-recordings. The doctor is able to change the scale-factor for the ECG-curves both in time-scale(X-axis) and in amplification(Y-axis). Regular status-information is retrieved from the database and processed as a trend-analyze for 24hours variations of R-R interval[5]. The doctor can choose the desired time-interval, and the graphs can be printed out for documentation .In separate field the doctor can make his comments on the actual recorded curves and to the alarm-conditions detected by the system. Doctor can overview the latest alarm recordings and what time they occurred and can also save the ECG curve for further prediction or for previous record.

Pan-Tompkins algorithm proposes a real-time QRS detection based on analysis of slope, amplitude, and width of QRS complexes. It includes a series of filters and methods that perform low pass, high pass, derivative, squaring and integration procedures.

A. Low pass filter

The transfer function for 2nd order low pass filter is given by:

$$H(z) = (1 - Z^{-6})^2 / (1 - Z^{-1})^2$$

$$Y[n] = 2y[n-1] - y[n-2] + x[n] - 2x[n-6] + x[n-12]$$

where the cutoff frequency is about 11 Hz and the gain is 36. All x-terms are divided by

36 to diminish gain. Then the final equation is given by:

$$Y[n] = 2y[n-1] - y[n-2]$$

$$+ (x[n] - 2x[n-6] + x[n-12])/36.$$

B. High pass filter

The transfer function for the high pass filter is:

$$H(z) = Y(Z) / X(Z)$$

$$= (1 + 32^{-16} + Z^{-32}) / (1 + Z^{-1})$$

The gain is 32 for this filter.All x-terms are divided by 32 to diminish by 32 to diminish gain. The final equation is:

$$Y[n] = x[x-6] - (y[n-1]$$

$$+ (x[n] - x[n-32])/32).$$

C. Differentiator

After filtering, the signal is differentiated to provide the QRS complex slope information. We used a five-point derivative with transfer function:

$$H(z) = 0.1(2 + z - 1 - z - 3 - 2z - 4)$$

The final equation is given by:

$$Y[n] = 0.1(2x[n] + x[n-1]$$

$$- x[x-3] - 2x[n-4]).$$

This derivative is nearly linear between 0 and 30 Hz.

D. Squaring function

After differentiation, the signal is squared point by point .The equation of this operation is:

$$Y[n] = (x[n])^2$$

This makes all data points positive and does nonlinear amplification of the output of the derivative emphasizing the higher frequencies.

E. Moving-window Integration(MWI)

The moving window integration extracts more information from the signal to detection a QRS event by averaging a certain number of sample per window. In such cases, the window must be the same as the widest possible QRS complex, and the length of the window must be selected carefully. Here ,at 200 sample per sec, the window's length is 30.The MWI process produces a signal wherein the peaks of the signal have been emphasized.

The equation of this operation is given by:

$$Y[n] = (x[n-(N-1)] + x[n-(N-2)] + \ldots.$$

$$+ x[n])/N$$

where N=30.

After the R-peaks in the QRS complexes are detected the heart rate is computed by measuring the length of the R-R interval, or a full period of the waveform. For the abnormal condition, Server will store the 1 minute ECG-recording and calculate the heart rate, variation in RR-interval and if desired by doctor, averaged values together with maximum and minimum values are calculated every one minute. These values stored in a status-file which regularly is transmitted to the server as an XML-file. The patient can thus receive messages and necessary drug prescriptions from the doctor.

III. EXPERIMENTAL RESULTS

In our experimental results, Fig. 2 shows the receiving ECG Data by RS-232 port at server terminal program.

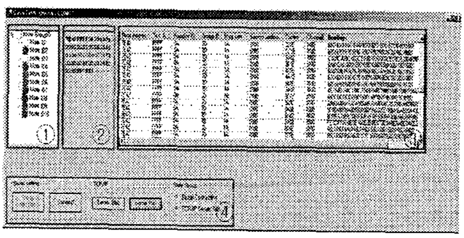

Figure 2: Receiving ECG data at Server Interface

In block1, the mote01 and mote03 are open and then the receiving data is shown at block 2. Received data classified into several field with respect to their packet format which is shown in block3.

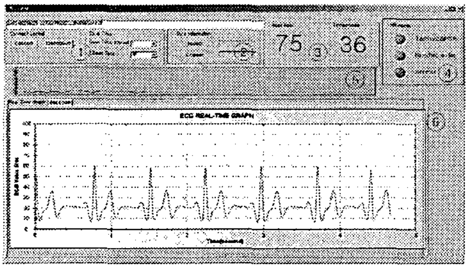

Figure 3: A Realtime human body ECG and body temperature graphic on terminal PC screen

Fig. 3 shows a Realtime human body ECG and body temperature graphic on terminal PC screen. The heart rate is 75 which indicates the normal condition of patient. Fig. 4 shows Real ECG signal graphic and observe heartbeat 121 which indicates bradycardia disease. Fig. 5 and Fig. 6 shows the normal and abnormal ECG on PDA. The red colored number expresses the body temperature of the patient.

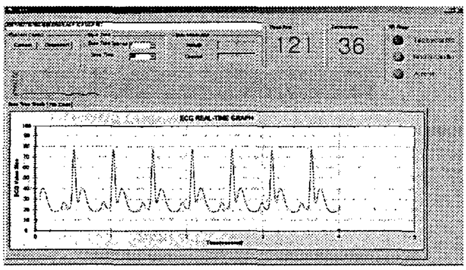

Figure 4: A Realtime ECG signal observe abnormal heartbeat

Figure 5: A real-time normal ECG monitoring at PDA

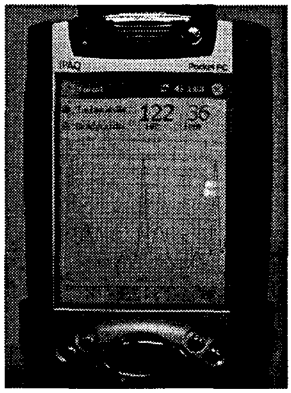

Figure 6. Abnormal ECG monitoring at PDA

IV. CONCLUSION

An ambulatory ECG monitoring prototype was developed as for the advanced monitoring system. Our system acted as a continuous event recorder, which could be used to follow up patients who had survived cardiac arrest, ventricular tachycardia or cardiac syncope-in both ambulatory settings and in hospitals. It therefore seems reasonable to assume that our new ECG-monitoring system will be able to, reliably, detect rarely occurrences of cardiac arrhythmias. Thus make correct diagnosis even under situations where the patient has the ability to carry out daily activity including physical exercise, body wash and normal work. In future a general large data-base can be added to provide monitoring for large number of patients in real hospital like situation. Also medication and treatment for patients can be maintained. Hopefully, our system will, after further refinement, be able to contribute to a better quality of life for patient by offering easy-to-easy use continuous ECG monitoring outside the hospital.

REFERENCES

[1] M. H. Crawford, "ACC/AHA Guidelines for ambulatory electrocardiography." Journal of the American College of Cardiology, vol. 34, pp. 912-48, 1999.

[2] R. Fensli, E. Gunnarson, and O. Hejlesen, "A Wireless ECG System for Continuous Event Recording and Communication to a Clinical Alarm Station," 26th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, pp 2208-1,2004

[3] Y. H. Nam, Z. Halm, Y. J. Chee, and K. S. Park, "Development of remote diagnosis system integrating digital telemetry for medicine," presented at Proceedings ofthe 20th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 1998.

[4] K. Y. Kong, C. Y. Ng, and K. Ong, "Web-Based Monitoring of Real-Time ECG Data,"Computers in Cardiology, vol. 27, pp. 189-192, 2000.

[5] I. Kobayashi, R Hayashi, A Sugawara, H. Matsumoto, "Telemetry system of daily life motion and arrhythmia,"In Proc. Eng. in Med. and Bio. Society (EMBS), Vol. 5, pp. 2229 - 2231, 1997

[6] J.Pan and W.J. Tompkins,"A real-time QRS detection algorithm" BME-32, pp.230-236, 1985.