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A MOBILE-PHONE ECG DETECTION KIT AND CLOUD MANAGEMENT SYSTEM

[1,2] SHUN-PING LIN, [2] WEN-HSU SUNG, [3] TERRY B. J. KUO, [2] JIN-JONG CHEN

[1] Office of Research and Development, China University of Science and Technology, Taipei, Taiwan
[2] Department of Physical Therapy and Assistive Technology, National Yang-Ming University, Taipei, Taiwan
[3] Institute of Brain Science, National Yang-Ming University, Taipei, Taiwan
E-mail: [1] shunping.lin@gmail.com, [2]shunping@cc.cust.edu.tw

ABSTRACT

The purpose of this study was to develop a mobile-phone electrocardiography (ECG) detection kit and ECG cloud management system to establish reference waveforms of cardiac activity, which is one of the most essential fields in preventive medicine. This paper presents a mobile phone detection kit that uses a Bluetooth transceiver module to obtain real-time ECG data, and which archives and transmits the data to a cloud database. This novel system possesses the following advantages: low cost, ultralow-power wireless transmission, light weight, and small volume, and contains an algorithm for comparing waveforms. In addition, the system contains a function that can provide the results to families or the physician using phone calls or text messages. The results exhibited highly similar outcomes, and this system enables personal operation and real-time recording and monitoring of ECG signals.

Keywords: ***arrhythmia, cloud ECG system, mobile phone kit, waveform comparison***

1. INTRODUCTION

The application of electrocardiography (ECG) signals for mobile monitoring of the human body was primarily based on heart rate (Armstrong & Bray, 1991; Freedson & Miller, 2000; Nelson et al., 2007). Recent rapid developments in electronic component manufacturing, product miniaturization, and reduced power consumption have dramatically increased the computing power of chips. By coordinating wireless transmission technology, the application of ECG signals is no longer limited to recording heart rates during daily activities, but can now be used to monitor real-time ECG signals when people are exercising (Jovanov, Milenkovic, Otto, & De Groen, 2005; Otto, Milenkovic, Sanders, & Jovanov, 2006). If measuring ECG signals becomes as convenient as measuring blood pressure, and is integrated into the monitoring of routine physical health, numerous cardiovascular problems can be detected and treated early. Therefore, developing a portable ECG detection system is an urgent concern(Zhou et al., 2004; Zhou, Hou, Ponsonnaille, Gineste, & De Vaulx, 2006). To avoid the complex operating problems of traditional ECG, the researchers in this study developed a wireless, low-power, light-weight, small, and easy-to-use ECG mobile phone kit (KY202BT). The kit combines the Bluetooth, Wi-Fi, and 3G signal transmission functions of a smartphone with global positioning system (GPS), telephone, and SMS communication features, and integrates powerful cloud storage and cloud algorithm capabilities. The algorithmic results of the ECG signals and information of the GPS coordinates can be transmitted to users and their family members or physicians.

2. PAPER PREPARATION

This mobile-phone ECG cloud management system (Fig. 1) contains a miniature ECG detection and Bluetooth transceiver module, mobile phone, a network device for storing signals, and a signal algorithm. These signals are transmitted wirelessly to the mobile phone and are displayed and uploaded synchronously to a network database by using 3G or Wi-Fi.

2.1. HARDWARE DESCRIPTION

The KY202BT was composed of four units: an analog amplifier circuit, a microcontroller unit (MCU), a Bluetooth transceiver module, and a coin battery. The hardware block diagram of the KY202BT is shown in Fig. 2. The ECG signals

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were amplified 250-fold, 1000-fold, 2000-fold and 1-fold, and were then filtered between various ranges of 1.6-113, 16-113, 0.034-53, 0.34-53, 0-8 and 0-10 Hz. The amplifier, INA333, which uses a high common-mode rejection ratio (100 dB) and low quiescent current (50 μA) and is manufactured by Texas Instruments, was employed. A 1.8V DC was used to supply power to the analog amplifier circuit and the reference voltage was 0.9 V DC. These signals were then relayed to the MCU, which sampled the signals at 250, 500, and 1000 Hz. After sampling, the signals were synchronously digitalized by employing an internal 12-bit analog-to-digital converter.

2.2. SOFTWARE DESCRIPTION

The developed software can be divided into two levels: low-level software, which involves the microcontroller, and high-level software, which is used in mobile phone applications and network operations.

2.3. TECHNICAL SPECIFICATIOONS

The technical specifications of this physiological recording system are presented in Table 1. The KY202BT is a light-weight and miniature recorder.

3. EXPERIMENT

For testing the KY202BT signal quality, an ECG signal patient simulator (MiniSim 1000, NETECH, USA) was employed as the standard. The MiniSim 1000 is designed for testing performance of basic patient-monitoring instrumentation quickly and easily.

4. EXPERIMENTAL RESULTS

ECG waveforms generally possess P-, QRS, and T-wave characteristics, which can be used to conduct further waveform quantitative analysis. ECG observation typically focuses on waveform characteristics, such as amplitude and time-scale changes. The signal recorded on the time scale, which is obtained from any lead, represents the electrical activity of the heart that is observed from various angles. Numerous heart problems can be determined according to variations in the waveform amplitude, polarity, form, length, appearance of additional waveforms, and heart rate.

The ECG waveforms of each person are different because of the location, angle, and size of the heart. Therefore, scholars frequently use a normal heart rate of approximately 80 BPM as the ECG reference standard (Fig. 3). In addition to observing changes on the R-R time scale, changes on the PQ, QS, RS, RT, and ST time scales and amplitude variations were observed. This experiment clearly presented subtle changes in time scale and amplitude.

4.1 TIME SCALE IDENTIFICATION

Fig. 4 indicates that the display clearly shows changes in the R-R time scale and subtle variation in the P-R time scale. This information can be used as a reference by physicians when interpreting signs of sinus arrhythmia, missing beats, atrial fibrillation, first-degree AV block, junctional premature contractions, and second-degree AV block (Mobitz I and Mobitz II).

Right Margin
1.25

4.2 AMPLITUDE IDENTIFICATION

Fig. 5 shows that the display clearly portrayed the amplitude of S-waves, which is greater than the amplitude of R-waves. This pattern is indicative of a left anterior hemiblock. These data can be used as a reference by physicians when interpreting signs of atrial flutter, paroxysmal atrial tachycardia, left bundle branch blocks, and premature ventricular contractions.

4.3 DATA FEEDBACK

Fig. 6 presents the waveform data feedback provided by the system to the user. The waveform indicates that the patient exhibits a continuous premature ventricular contraction abnormality. The proposed system can store the digital ECG signal on a network data server and use MMS to transmit the data to users, family members, family physicians, or health care centers. This system can provide a vital service to the health care industry in the future.

5. CONCLUSION

A light-weight, miniature, convenient, non-invasive, wireless, and real-time physiological recording system was designed and tested successfully. Both physicians and patients can benefit from using this system, including in the fields of preventive medicine, health care, and sports medicine. In addition, this system can be applied in clinical research, telemedicine, and to personal health databases.

6. ACKNOWLEDGMENTS

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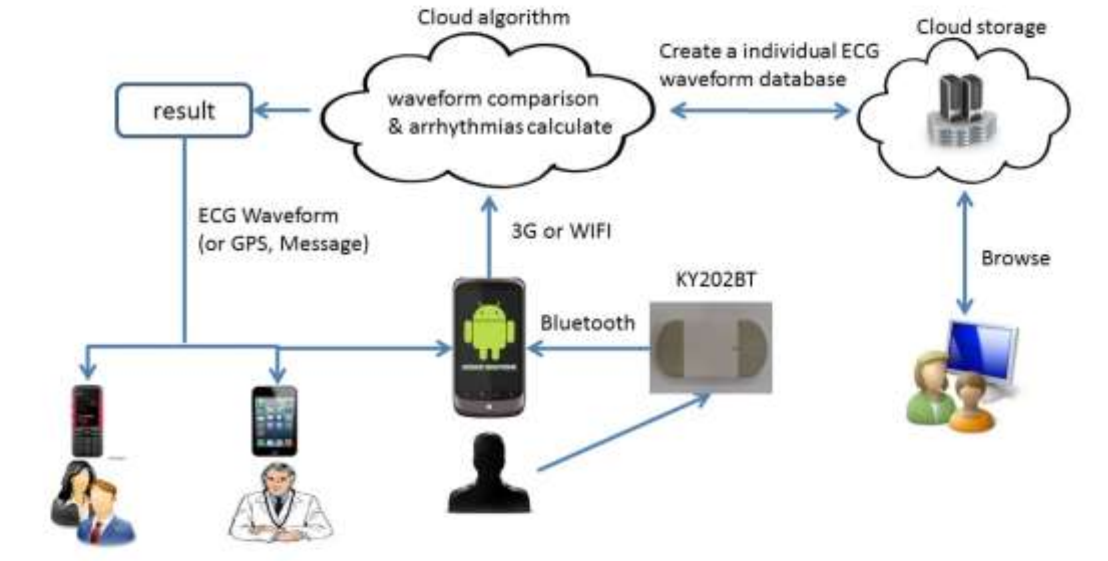

Figure 1 : The mobile-phone ECG cloud management system.

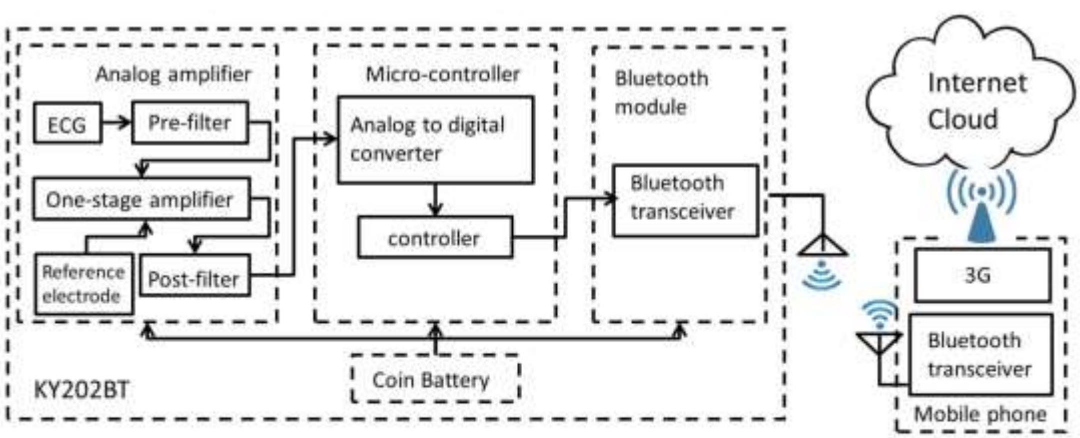

Figure 2 : Block diagram of KY202BT sensor.

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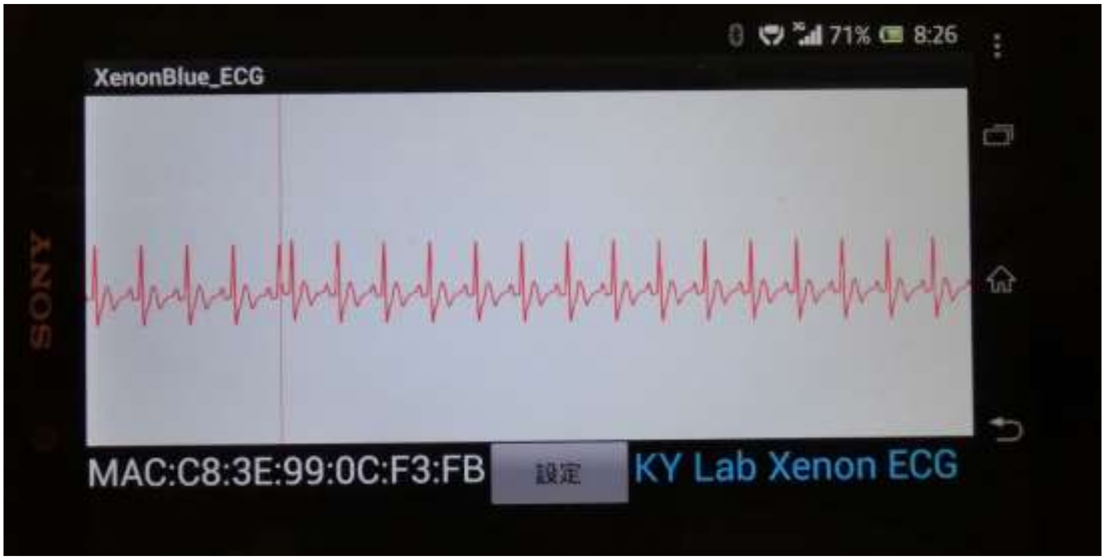

Figure 3 : Normal sinus rhythm (NSR) at 80 BPM is the default waveform.

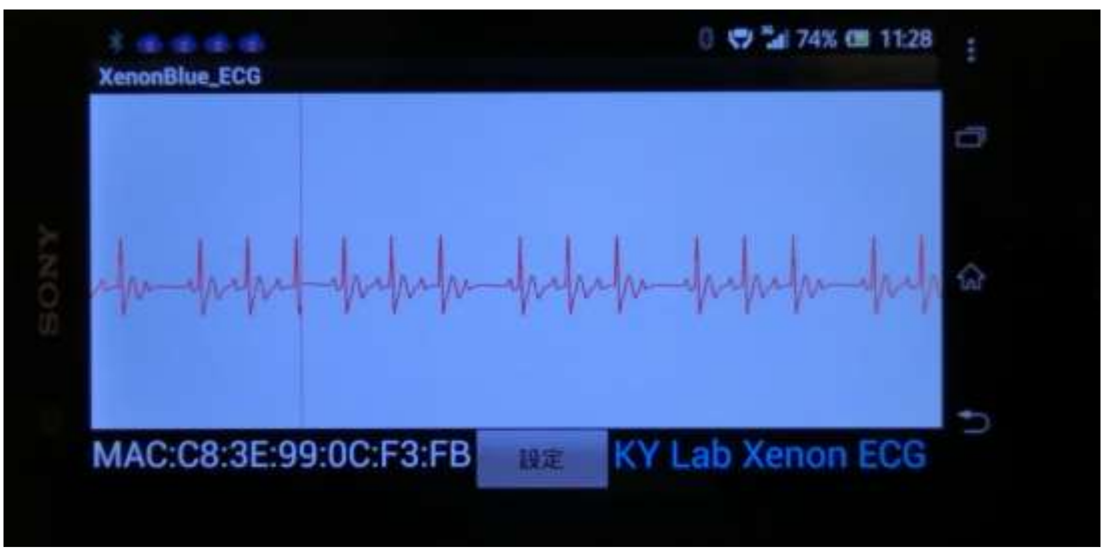

Figure 4 : The screen displays the progressive extension of the P-R interval and intermittent loss of beat.

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Figure 5 : The screen shows that the S-waves are greater than the R-waves in this patient.

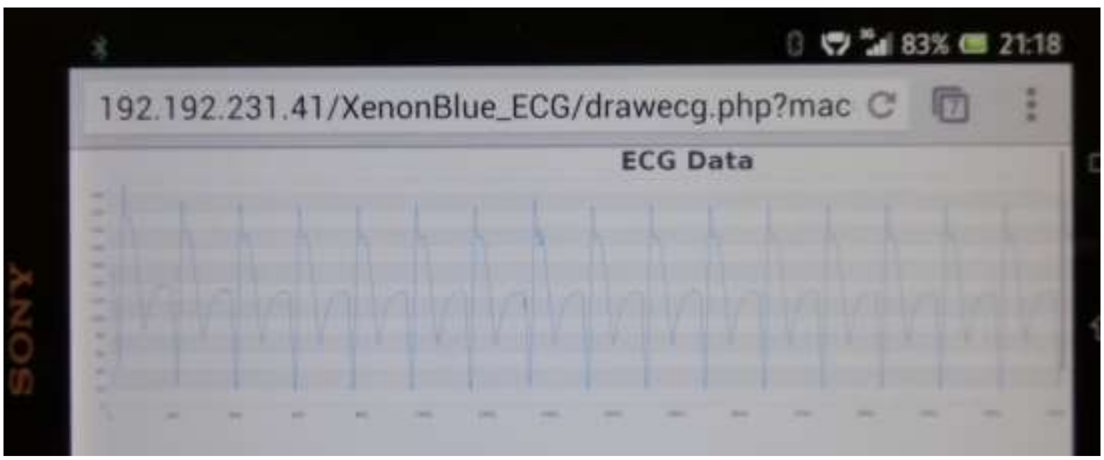

Figure 6 : The waveform transmitted using MMS shows a continuous premature ventricular contraction abnormality.

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Table 1: Technical specifications of this detector

KY202BT	
Weight	8.6 g
Dimensions	5.5 × 3.5 × 1.2 cm^3
MCU	TI-MSP430BT5190
Bluetooth	2.0 version
Bluetooth transceiver	Panasonic, pan-1315
Bluetooth transmission power	≦ 10 mA
Bluetooth transmission range	10 m
Operation time	≧ 50 h
Power consumption (standby mode)	≦ 0.1 mA
ECG signal format	European Data Format (EDF)
ECG amplifier	Analog device, AD-8607
Analog-to-digital converter	12 bit
Battery	Coin 2032, 3 V, 230 mAH