Wireless Heart Rate Monitor in Personal Emergency Response System

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***Abstract* — This paper presents a remote heart rate monitor in personal emergency response system. It is intended for continual monitoring of the heart rate of the elderly with long term cardiovascular disease in care homes or their private homes. The system was implemented using smart audio alerting technique. Results show that the system can detect abnormal cardiac rhythms in real-time. In addition, the system was able to contact an authorised clinician in a remote location during an emergency situation. The developed system can extend the telemedicine application with a wide range of possibilities.**

Keywords - Heartrate, Electrocardiograph, Personal emergency response system, telemedicine.

I. Introduction

The growing number of elderly people living with one or more long term health risks such as heart attack is posing greater challenges on health care services. In the UK and other advanced countries, health care budgets are reaching breaking point as increasing expenditure is directed towards them [1]. To combat those challenges, a number of measures have been adopted to decrease the burden associated with aging by implementing an effective health intervention program which targets the main courses of illness and death. Monitoring of electrocardiograph (ECG) information in real-time is crucial in the management of chronic disorders. Real time monitoring would allow not only emergency detection in physiological data but provide existing data to evaluate the risk of heart failure [2]. A Wireless ECG technology in personal emergency response system (PERS) utilises self-organising networks of lightweight battery-operated wireless sensors. It detects changes in the body's electrical activities and automatically alert clinicians in an emergency situation.

Numerous studies of wireless ECG monitoring system have targeted the elderly; however, less have been reported on using audio approach to alert the medical professional when they are in extreme difficulty. Most of all, the ECG devices in PERS application have concentrated on sending real-time pulse signal data to a remote based without the physical interaction [3], subsequently, recording huge unreliable physiological data [4] and fails to compliment care providers cognitive capabilities and needs [5]. Furthermore, there is evidence that, intuitively, clinician's psychological interactions are key elements of patient perception of quality of care [6]. ECG in the telemedicine application deals with life-critical data, thus, a lost frame or packet can cause an alarming situation to be totally missed or misinterpreted [7]. Some of these monitors cannot accurately distinguish between normal daily activities and life threatening conditions.

To address the situation where the medical professionals do not merely attend to the patient due to false alarm, this paper presents a telemedicine system based on smart audio approach. A software algorithm in the sensor analyse the pulse signal for changes in the heart rhythm. As soon as the heart rate is above a threshold, the authorised medical professional phone number is dialled automatically. Once a communication is established between the two phones, any sound from the elderly in an emergency situation is listened to by the caregiver. Based on the surrounding audio feedback from the elderly, the remote caregiver is well informed as to what action to take. Moreover, the emergency team attending to the patient can offer assurance while accessing detail information before they arrive.

Section II describes the materials and method used in this study, including the operation, circuit design and a method to accurately extract the QRS complex and audio alerting system. In section III, measurement and discussion of result is presented. Finally, the conclusion is drawn in Section IV.

II. MATERIAL AND METHODS

A. System block diagram

As Fig. 1 shows, the system comprises of four key units- including a transducer unit that captures the heartbeat from the patient's skin to the control unit. The electronic control unit provides the platform where a control application program is written to process the ECG signal, monitoring and sending a communication signal once the heartbeat reaches a dangerous level. The communication unit serves as a communication link between the monitored person and the clinician. Power is probably the most vital unit since it provides the power necessary for the normal operation of all the sub-units.

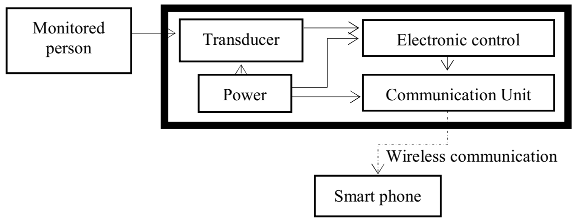

Fig. 1. Block diagram of wirelss heart rate monitor in personal emergency response system.

B. Circuit design

The front end of the ECG was designed to capture the pulsating of the perforated artery of the finger. The photodiode is positioned in such a way to generate a current proportional to

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changes of infrared light passing through the fingertip. The changing current produced by the photodiode as a result of the infra-red (IR) illuminating will develop a corresponding voltage across the resistor. The weak ECG level amplitude between 100µV and 4mV [8] is amplified to a required level for detection and processing. Most mobile phones are now equipped with Bluetooth which provides real time data and voice transmission speed. The system incorporated an audio enabled Bluetooth module linking the microcontroller. By configuring the Audio Gateway (AG) service within the Bluetooth Hands-Free-Profile (HFP) module, a wireless link is established between the microcontroller and the Bluetooth compatible phone.

The P, QRS and T spectrum of the heart beat varies, however, duration of parameters such as the RR interval is useful for detecting the heartbeat. Here, the first derivative with adaptive quantised threshold algorithm was applied to detect the R wave [9]. By counting the number of peak value of the QRS-feature signal which had cross the threshold, the heartbeat is computed and stored in the on-board memory. If any abnormal heart beat is encountered, the microcontroller automatically activates the Bluetooth module, subsequently, automatically dialling an authorised caregiver's stored phone number.

To verify the performance of the implemented system as compared to standard heart rate monitor from OWIM GmbH & Co.KG. A user wearing both sensors was required to perform two activities; sitting and brisk walking. The output of our system was connected to a digital oscilloscope where the trace of the heartbeat could be detected and measure.

III. RESULT AND ANALYSIS

The heart beat measured from the standard ECG and the PERS is presented in Fig. 2a and b, Analytical comparison indicated that on the average, the standard ECG recordings tend to be higher than our system. The maximum percentage difference was found to be 3%. The source of this difference was credited to the time delay as measurement could not be done at the same time. The result however suggests that the system could detect the heart rate signal.

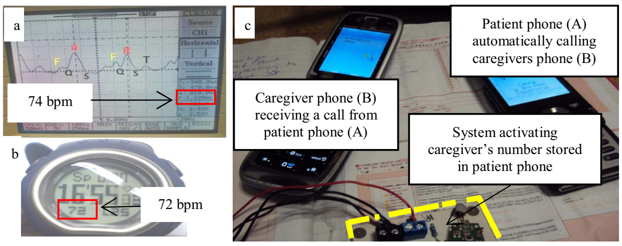

Fig. 2. Typical heart beat recoded simultanousely from: (a) implemented system and (b) standard system. PERS dialing a caregiver's phone (B) when heartrate abnormality occurred (c).

An evaluation of the system was also carried out to determine its response to automatically call a caregiver's phone number once a heartbeat abnormality has been detected. As illustrated in Fig. 2c, Two Bluetooth compatible mobile phones were used. "A" represents the patient mobile phone while "B" represents a caregiver in a remote location. The user was instructed to wear both systems while running, thus depicting an emergency condition where the heart rate exceeds 100 bpm. From Fig. 2c, it can be noted that once the heart rate exceeded 100bpm, the patient mobile phone (A) was automatically activated to call the caregiver phone (B) by the Bluetooth HFP module on our system.

The distance of mobile phone (B) did not matter so far as it was within the coverage area of the mobile network provider. The communication between the patient mobile phone and the transducer however was limited to the Bluetooth signal which in this case was only 10meters. For this reason, when mobile phone (A) was placed at a distance greater than 10meter from our system, the caregiver could not receive any call from the patient.

IV. CONCLUSION

The paper has presented a heart rate monitor system with wireless communication using smart audio alerting approach. This system acquired, processed and monitored ECG signal in real time. Once it identified any abnormal cardiac rhythms, it automatically dialled an authorised caregiver phone number and by that, a voice communication was established between the patient and the clinician. This system has shown to provide both psychological and biomedical care which is vital to patients with long term conditions and the caregiver tracking the cardiac-rhythm disorders. Large sample testing of our system is needed to determine its robustness.

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