A Cell Phone-based ECG, Blood Pressure Monitoring System for Personal Healthcare Applications using Wireless Sensor Network Technology

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ABSTRACT

Electrocardiogram (ECG) and blood pressure (BP) are main vital signs which are the standards in most medical settings in assessing the most basic body functions. Multi parameters are desired in providing more information for health professionals in order to detect or monitor medical problems of patients more precisely. This study urges us to develop a robust wireless healthcare monitoring system which has multiple physiological signs measurements on real time that applicable to various environments which integrates wireless sensor network technology and code division multiple access (CDMA) network with extended feature of locally standalone diagnosis algorithms that implemented in cell phone. ECG signal and BP parameter of the patients are routinely be monitored, processed and analyzed in details at cell phone locally to produce useful medical information to ease patients for tracking and future reference purposes. Any suspected or unknown patterns of signals will be immediately forwarded to hospital server using cell phone for doctors' evaluation. This feature enables the patients always recognize the importance of self-health checking so that the preventive actions can be taken earlier through this analytic information provided by this monitoring system because "Prevention is better than Cure".

Keyword

ECG, BP, Physiological Signs, Diagnosis Algorithm, Self-health Checking

I. INTRODUCTION

The healthcare industry is dynamic and filled with challenges. In fact, the trends have been clear and present for some time: a steadily increasing elderly population, a better informed populace who demand specialized, interactive treatment and care. The main challenge is how to provide better healthcare services to an increasing number of people using limited financial and human resources.

With an increasingly mobile society and the worldwide deployment of mobile and wireless network, many healthcare applications can be supported by wireless infrastructure which brings tremendous potential like reduce the long-term cost and higher overall quality of healthcare services for today's healthcare industry [1]. Implementation of wireless technology enables patients can be monitored anywhere, anytime and would not be impeded by the physical constraints imposed by the cables which has been used extensively in home healthcare. The patients can be monitored remotely, receive the highest levels of care and have the freedom to live life as best they can. This can allow the healthcare providers minimize the time that a patient spends in hospital where resources are specialized and expensive. The cell phone is the most logical and convenient access point for healthcare applications since it is low hardware costs and widely be used.

In this paper, we proposed Mobile Care Monitoring System for patient self-health checking. This mobile monitoring is a wireless, lightweight system that uses sensors connected to medical devices to measure vital values like electrocardiogram (ECG) and blood pressure (BP) in real time continuously. The patient is attached with number of sensors connected to a cell phone. Vital values are measured and sent

to the cell phone via wireless sensor network, stored and analyzed on cell phone, and send the information from cell phone to the doctor over code division multiple access (CDMA) network. Mobile monitoring is adapted to suit patients' individual needs and guarantees the highest level of accuracy.

II. SYSTEM DESIGN

Fig. 1 shows the framework of this Mobile Care Monitoring System consists of device, communication and management layers. The device layer includes sensors and wearable devices such as chest belt and wrist blood pressure monitor device which are integrated with ECG signal and blood pressure parameter which can gather and send the collected medical data to monitoring program beyond hospital or to wireless dongle and then relayed to hospital through cell phone.

The communication layer acts as a middle layer to connect between the device layer and management layer to perform data or command exchange through IEEE 802.15.4 and CDMA networks. The management layer includes a web server to receive the data and respond upon the request to and from the cellular network. A monitoring program in server is developed to monitor the vital signs of patients continuously and only the abnormal data will be routed to terminals in the hospitals. The patient's database is used to record patients' personal medical information.

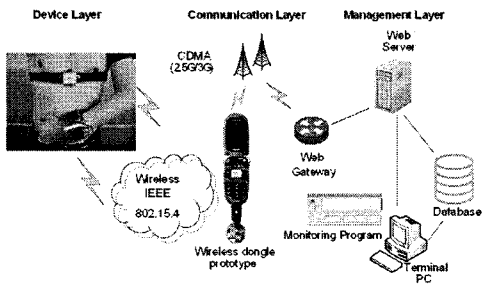


Fig. 1. System Architecture of Mobile Care Monitoring System.

The wireless sensors are used to capture ECG and BP channels accordingly and transmit those signal data via wireless to cell phone. The cell phone acts as a local processor which embedded with ECG and BP processing algorithms to process data in real time. Only abnormal medical data will be sent over cellular network to hospitals to alarm physician. This is to avoid flooding of telecommunication channel and high transmission cost. The data is packed into data packets using self-designed enhance communications protocol, High-level Data Link Control (HDLC).

III. ECG PROCESSING

The model name of this cell phone is used for this project is Samsung SCH-V670 as shown in fig. 2. The data received from the ECG sensors are processed in real time in the cell phone locally to decode the data. The ECG processing has two stages which are QRS Detection Module and Decision Rule Module that based on a set of if-then rules. Our QRS detection algorithm is based on the originally developed QRS detection algorithm by Pan Tompkins [2] which consists of digital bandpass filter, differentiation, squaring and moving window integration steps as shown in fig. 3.

Fig. 2. Diagnosis program at cell phone.

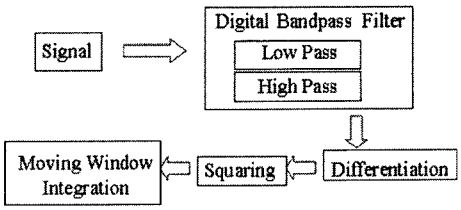


Fig. 3. Processing procedures of QRS detection algorithm.

The information of real-time QRS detection bases on analysis of slope, amplitude and R-to-R interval which is important for Decision Rule Module to determine the abnormality of ECG signals. For the signal where its width is less than 100ms and R-to-R interval is between 0.8s and 0.9s or the width less than 60ms and

the R-to-R interval exceeds 1.1s are categorized as normal ECG waveform as shown is fig. 4. If not, abnormal or unknown waveform will be send to the server monitoring program for further analysis.

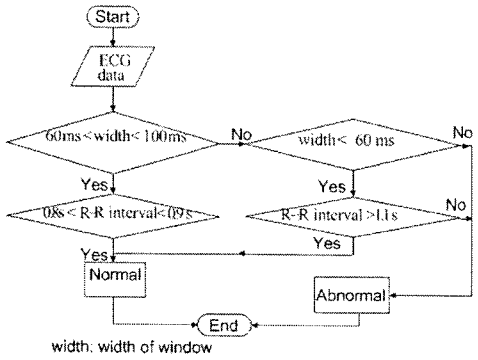


Fig. 4. Processing algorithm of ECG analysis.

IV. BP PROCESSING

BP measurement is necessary desired because we strongly believe that merely ECG parameter cannot provide enough information for doctor to make correct evaluation of patient since BP is the most commonly measured physiological parameter often taken by doctor to assess the most basic body functions.

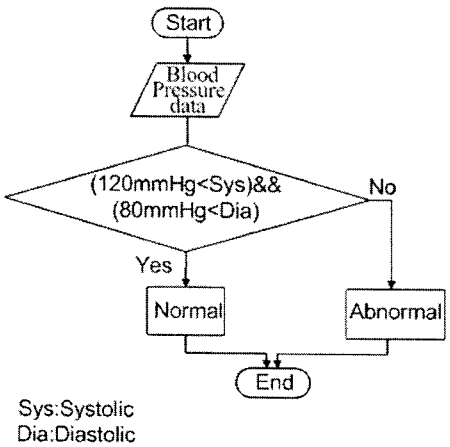


Fig. 5. Processing algorithm of BP analysis.

There are two reading numbers for blood pressure - systolic pressure over diastolic pressure. According to National Heart Lung and Blood Institute (NHLBI) [3], the typical values for a resting, healthy adult human are 120mmHg (millimeters of mercury) systolic and 80mmHg diastolic as shown in fig. 5. The data received from the BP sensor connected to wrist BP monitor device as shown in fig. 6 are in real time processing in the cell phone base on BP processing algorithm.

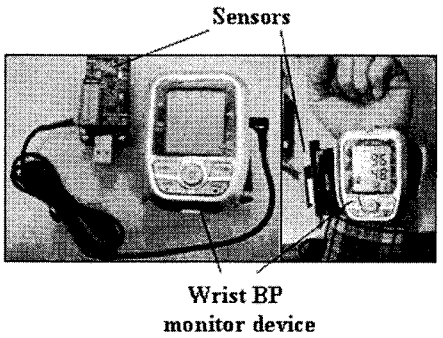
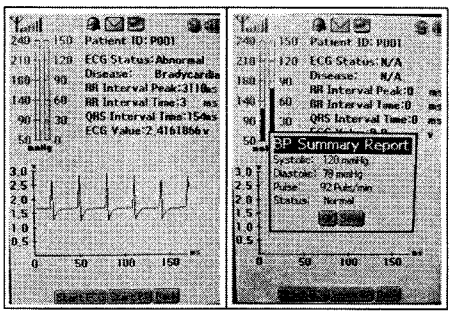


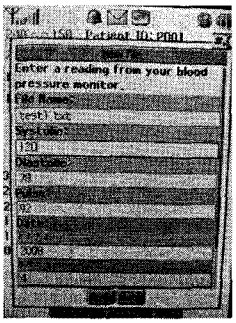
Fig. 6. Sensor is connected to wrist BP monitor device.

V. EXPERIMENTAL RESULTS

Our experimental set-up uses the ECG and BP sensors attach to the real human body to validate the framework that we have proposed and implemented. The data are transmitted from the sensors via wireless sensor network to the wireless dongle that connected to cell phone with embedded diagnosis program. ECG waves are able to be monitored by detecting QRS complex and its normality can be determined at the same time in the cell phone. The abnormal vital signs are relayed to the monitoring program at server for further evaluation.



(a) (b)



(c)

Fig. 7 (a-b) Screen captured of ECG and BP diagnosis program at cell phone, (c) medical records are saved at own cell phone locally.

Fig. 7 shows (a) normal ECG graph with normal status of patient and additional information available such as status, suspected disease, RR interval peak, RR interval time, QRS interval time and ECG value, (b) normal blood pressure measurement with a summary report screen displayed includes systolic, diastolic, pulse and normal status of patient in the diagnosis program. Patient can save his/her own medical record in cell phone locally for future reference as shown in (c). This feature enables the patient always aware about his/her health condition so that the prevention action can be taken earlier through the information provided by this monitoring program.

VI. CONCLUSION

A prototype of ECG and BP analysis with activity monitoring was designed and implemented which integrated wireless sensor network technology and mobile applications to build an efficient monitoring system. Implementation of simple ECG and BP analysis at cell phone not only benefits patients on diagnosing their health condition periodically but also reduces the overall hospitalization period and cost by alerting the medical staff for any occurrence of any emergencies.

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