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A Portable Wireless ECG Monitoring System using GSM Technique with Real Time Detection of Beat Abnormalities

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Abstract : ***In this mobile era, design and development of a continuous remote ECG Monitoring System will be of immense help to modern healthcare. Deploying telemedicine/telecare principles, the developed system suggests a feasible solution for continuously monitoring the post-operative conditions of cardiac patients. When the product developed is small in size and exhibits user-friendly operations the patients will feel more comfort in carrying them. The mobile phone technology which has gained tremendous popularity when used as an inter-link between the patient and the physician will be a familiar platform for both of them. Our paper proposes the design of a real time, low cost portable wireless ECG acquisition system which we implement through the common mobile phone and high end recorder. An Alarm system with a notification mechanism is an added benefit to alert both the physician and the patient in case of any abnormalities.***

Key Words: Telemedicine, ECG acquisition, wireless system, GSM, Telemetry.

I. Introduction

Cardiovascular disease is the world's leading killer, accounting for 16.7 million or 29.2 percent of total global deaths.[xi] Heart disease continues to be the leading cause of mortality in day today life in an era of industrialization, changing lifestyles and dietary habits. The mortality rate reported in government hospitals shows an increase in death due to heart diseases and this trend is expected to continue into the next decades. Since cardiac disorders are increasingly affecting human lifestyle and rehabilitation, some practical devices based on modern technological explosions are inevitable and created to reduce the disability from heart diseases.

The main aim of this paper is to develop remote health monitoring system to monitor online medical parameters which can reach the nodal unit from everywhere. Because of the lesser cost in wireless communication technologies, implementation of them to advanced telecommunication techniques are being used and some standards are determined for ambulatory electrocardiography. The monitoring systems are examined in two groups as real time systems and store and forward systems. Today, lot of commercial portable Holter monitoring systems and cardiac event record systems are being commercially available. But in this types of systems, ECG electrodes are connected to the recording unit with cables. Beside, the systems mentioned above, systems that uses wireless local area networks (WLAN) and GSM/GPRS are proposed.

Here we are trying to implement a portable monitoring system with wireless transmission in which the acquired ECG signals are processed in a controlling unit(node unit) to detect for abnormalities. If there is any abnormality, an alarming notification is sent to the physician's mobile. This solution not only gives patient more freedom, but also provides early diagnosis of cardiac diseases with its alarming properties.

II. Related Work

A. Aleksandrowicz. et. al [iii] proposed their capacitively coupled ECG measurement system which is more sensitive to moving artifacts. This is useful for heart rate detection in long term applications. The drawback of the system is that an adequate distance between the surface of the electrodes and subject's body is necessary for a high quality ECG measurement.

Eurique Mario Spinelli et. Al [vii] proposed their transconductance driven right leg circuit to reduce common mode interference. They implement a system which provides an extended bandwidth for high frequency EMI rejection and easy to compensate for stability. They also achieved a comparative analysis between a typical driven leg circuit and the proposed system.

Kyungtae Kang et.al's [vi] medical grade WLAN architecture for remote ECG monitoring employs the point co-ordination function (PCF) for medium access control and reed Solomon coding for error control. The basis of their proposal is to split the MAC layer into MAC and LLC layers. The new MAC layer uses the IEEE 802.11PCF mode to achieve deterministic packet delivery, and the LLC layer uses RS-based error control with block interleaving to achieve high reliability.

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Data for simulation are from the MIT-BIH database. It shows how the proposed architecture can improve wireless network performance to the extent necessary to support a telecardiology application.

Yong Gyu Lim. Et.al [xii] presents a convenient method of ECG measurement for long-term, everyday monitoring without direct conductive contact with the skin while subjects sat on a chair wearing normal clothes. Electrodes with high-input-impedance amplifiers mounted on it are used for measurement and have an indirect- contact grounding. The providers face a limitation of lower signal quality than those of conventional methods and the results depend on clothing properties.

In the above works, they use an ECG electrode to record the bio-signal. The patients and physicians need to be stationary for the entire process. Even though they follow wireless transmission (architecture) scheme, the distance between the patient and the physician has to be taken into account. In our system we are trying to implement a reliable continuous wireless patient monitoring system where the distance is not a limiting parameter and the system enhances the mobility for both patient and the physician.

III. Methodology

Figure 1 shows the block diagram of the proposed system. The proposed system comprises two modules (i) Bio signal acquisition module (ii) Controller Module

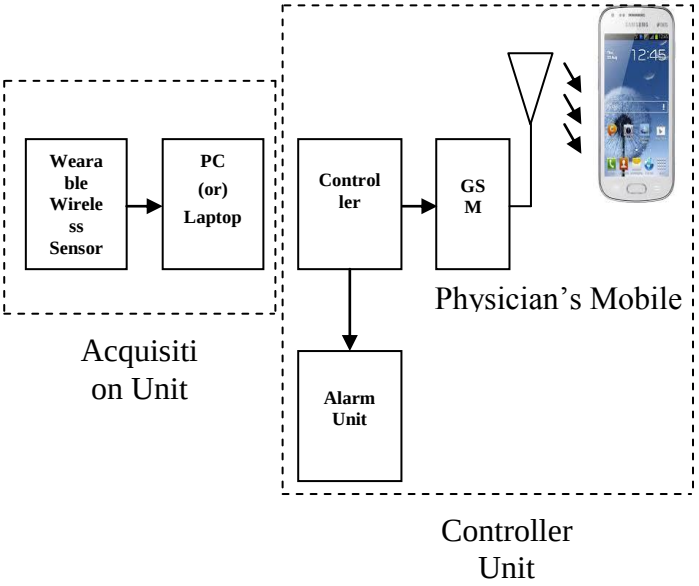

Figure 1. Block diagram of the system

A. Bio- Signal Acquisition

The bio-signal acquisition module consists of wireless ECG sensors placed over the patient's chest for recording the heart rate and ECG signal. The recorded signal is a II lead ECG. This heart rate is now transmitted to the pocket PC or Laptop wirelessly. The next module consists of a PC, PIC controller and a GSM modem

The signal from the laptop or pocket pc will be able to visualize the ECG signal along with the heart rate. This heart rate is further sent to the controller unit by means of RS232 communication port. The controller compares the received heart rate with the normal person's heart rate. If the controller detects any variation from the received signal to the normal person's heart rate it automatically sends the alarm notification to the physician's mobile and to the patient's mobile along with the abnormal heart rate by means of GSM modem.

Therefore this system gives patient more freedom of mobility and also provides early diagnosis of cardiac diseases with its alarming properties.

B. Controller

PIC 16F877A microcontroller is used as a controller for comparing the received heart rate with the normal person's heart rate to detect if there is any abnormality. The overall operation of the controller is shown in figure 2.

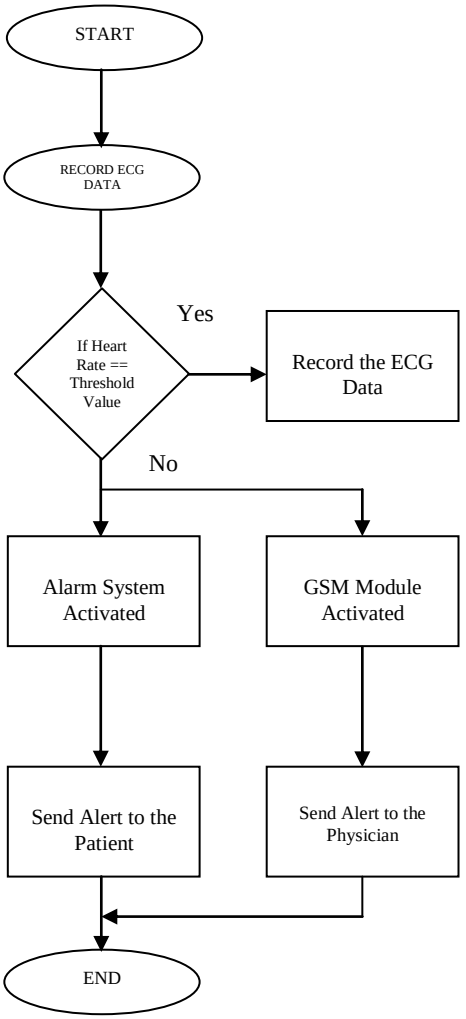

Figure 2. Overall Operation of the Controller Unit

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When the controller receives the signal (heart rate) from the wireless sensors, the received signal is then compared with the predefined threshold value which is stored in the controller. If any variation is detected in the received signal, the GSM module get activated using AT commands which sends the abnormal heart rate to the physician through patient's mobile via SMS and the alarm system is also activated. The threshold value is taylor made and it is not set as default. False alarm rate is cleared in the training and test period itself.

IV. Software Description

The software developed can be divided into two levels: Low level software associated to the microcontroller, and high level software for the applications in the PC and wireless sensors.

A. Microcontroller: Low Level Software

The PIC microcontroller has been programmed to capture and digitize the ECG signal and initiate the GSM module to transmit the data. The GSM module is initiated by means of AT commands.

B. Wireless Sensors and PC: High Level Software

This application is used to monitor the real time ECG signal from the patient and storing them if the user requires it.

V. Results and Discussions

Figure 3.1 and 3.2 show the experimental setup of the wired & Wireless ECG monitoring system.

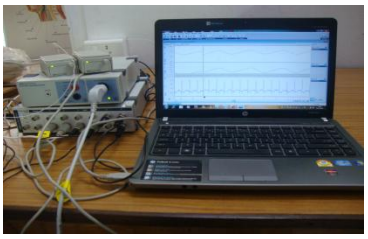

Fig 3.1. Wired ECG Monitoring System

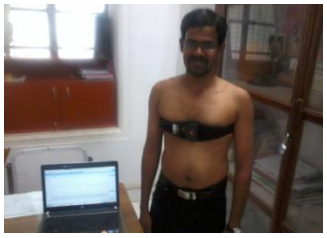

Fig 3.2. Wireless ECG Monitoring System

The Results for the wired ECG monitoring system is shown in figure 4.

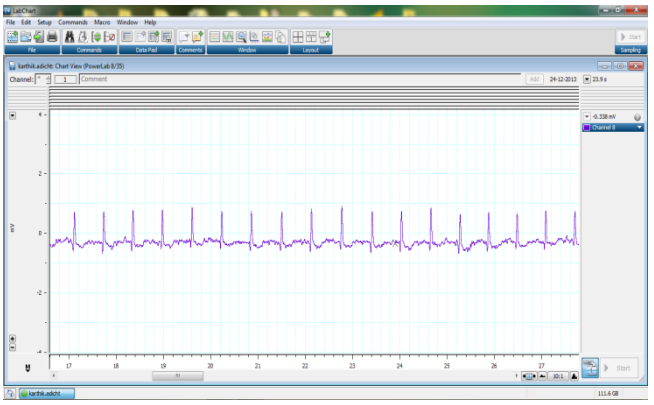

Figure 4. Experimental Output Using Wired ECG

The Results for the wireless ECG monitoring system is shown in figure 5.

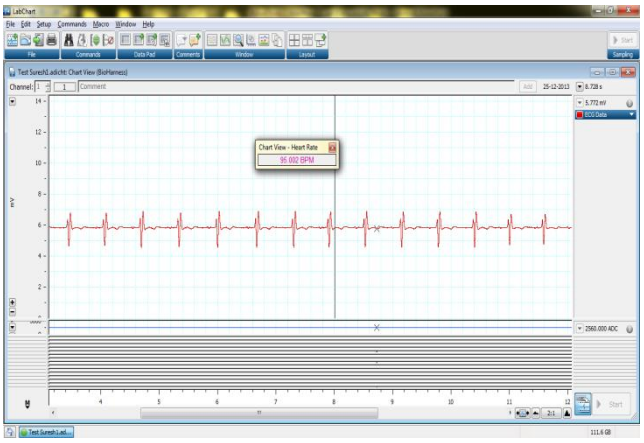

Figure 5. Experimental output using wireless ECG at heart rate 95BPM

The heart rate received from the wireless sensors are then fed into the PIC controller. This received heart rate is then compared with the predefined stored threshold value in the controller to detect whether there is any abnormality.

The accuracy & distance achieved from the wireless with respect to the wired ECG is shown in the figure 6.1 &6.2.

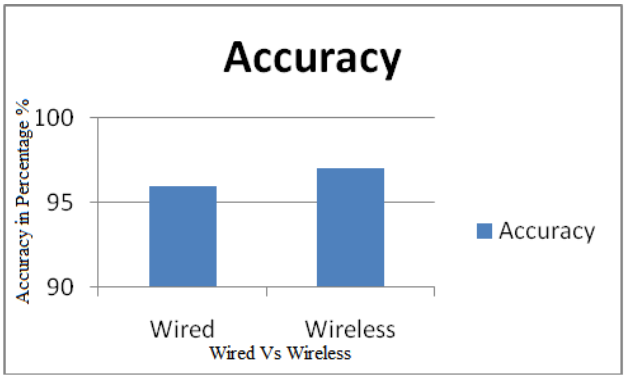

Figure 6. Comparison of Wired & Wireless with respect to Accuracy

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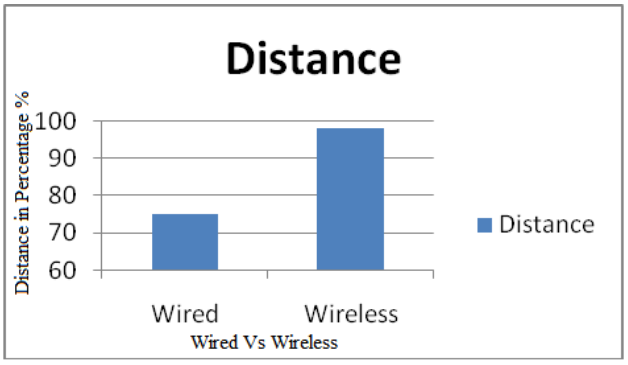

Figure 7. Comparision of Wired & Wireless with respect to Distance

VI. Conclusion

We have developed a system for long term monitoring of cardiac patients which enhances the mobility for both the physician as well as the patient. By deploying GSM & wireless technology, the performance of the monitoring system is enhanced and which provides real time continuous monitoring of the patient enabling the physician to be aware of the cardiac functioning of the patient at a distance.

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