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Athlete's ECG Monitoring System using Wireless Sensor Networks

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***Abstract*—** Athlete's physiological signalsduring practice and competitions are very useful to safeguard their life from severe life threatening diseases and injuries. Among the various physiological signals such as Electroencephalography (EEG),Electromyography (EMG), Electrocardiogram (ECG) etc. the most important and the challenging one is ECG.In this paper, we have proposed a wireless ECG signal monitoring system with Raspberry Pi microcontrollerthrough which the ECG signal is acquired and analyzed.A special type of sensor device with surface electrodes called SHIMMER is used to acquire the ECG signal from chest of the players. SHIMMER has inbuilt microcontroller MSP 430 which converts analog ECG signal into digital data and also support low power wireless communication for the transmission of digital data to the external device based on the standard IEEE 802.15.4 and ZigBee. The data is either stored or transmitted from SHIMMER to ZigBee receiver which is connected to ECG signal monitoring system with Raspberry PI controller. Therefore the real time ECG signal of the Athlete is acquired, analyzed using Raspberry PI. These data can also be stored in a micro SD card for further analysis to detect the abnormalities in the wave such as Arrhythmia, Atrial fibrillation, Tachycardia, Bradycardia.

Keywords —Electrocardiogram, SHIMMER, Raspberry Pi, ZigBee module.

I. Introduction

Heart functionality of athletes need to be analyzed during practice and matches, since heart diseases are primary cause for athletes' mortality. Heart is avital part of the human body that is responsible for the functioning of the body which pumps blood and gases in and out of the body. It is primarily divided into four chambers: the upper left and right atria, the lower left and right ventricles. Also one important feature about the functioning of the heart is that the blood flows only one way through the heart valves because these prevent backflow. The right and left heart has various functions. The right heart collects the de-oxygenated blood in the right atrium from the body and pumps it through the tricuspid valve via the right ventricle by the passive process of diffusion. In the left heart, the oxygenated blood is returned to the left atrium via the pulmonary vein. It is then pumped into the left ventricle through the bicuspid valve and into the aorta for systemic circulation. The heart does not only pump blood and gases but it is also responsible for electrical activities [1].

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The electrocardiogram (ECG or EKG) is a bioelectrical signal which is measured noninvasively to analyze the electrical activity of the heart. An ECG can be used to measure and identify the heart rate and rhythm of the heart, presence of any heart disorders, the balance of salts in the blood and the effects of drugs and artificial devices used to regulate the heart [2]. An ECG usually requires a trained clinician to interpret it. During any physical activity the ECG measurement and analysis will cause difficult for the athletes. So it is important to use a wireless mode of transmission after acquiring the signal from the athletes.The electrical activity of the heart during the practice can be measured real time using a wireless ECG monitoring system to find out any abnormality and disease condition of the heart such as atrial fibrillation, ventricular fibrillation, myocardial infraction, heart failure.

In this paper, we have proposed a wireless ECG signal monitoring system with Raspberry Pi microcontroller through which the signal is acquired and analyzed. A special type of sensor device with surface electrodes called SHIMMER is used to acquire the ECG signal from chest of the players.Literature show that for wireless ECG transmission RF technique can be used [3]. But in this work, latest wireless technology ZigBee that has been used that has more advantage than RF technique.

II. Materials And Methods

The proposed system consists of a two main components: SHIMMER and Raspberry Pi controller. The SHIMMER is kept on the chest of the athlete that measures the heart rate and receives the data from the athlete, stores it and transmits it to the Raspberry Pi microcontroller. The Raspberry Pi receives the data. This is analyzed and compared with the normal ECG wave to detect any abnormalities. The figure 1. Explains the basic block diagram of the proposed model.

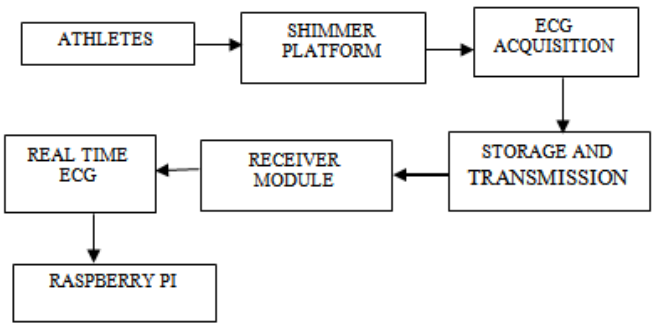

Figure 1. Block Diagram of the proposed model.

a) Shimmer

In general, a typical sensor node or *mote*-- should consists of a microcontroller, one or two transceivers for transmitting and receiving the data, external or internal memory for storage of the data, one or more sensing elements and a power source. In this proposal, SHIMMER platform is used as a sensing element for collecting the ECG data from the players. This SHIMMER has certain unique feature with an inbuilt TI MSP430 microcontroller with 10KB RAM, 16KB EEPROM, for program code it has 48KB flash memory and 1MB external flash memory for data logging. The communication module supports IEEE 802.15.4 and ZigBee standards with CC2420 transceiver, which operates in 2.4GHz ISM band and it permits data rates up to 250Kbps. It has 12- bit Analog to Digital converter through which data acquisition is done up to 8 channels. The SHIMMER platform is mainly used to record and transmit physiological and kinematic data. It has different kinds of expansion modules which include several physiological sensors such as EMG (Electromyography) and ECG (Electrocardiography) and also have kinematic sensors 3-axis low field magnetic sensing and 3-axis angular rate sensing.

The ECG expansion module of the SHIMMER platform provides LA-LL (Left Arm – Left Leg) and RA-LL (Right Arm – Left Leg) input leads. The other lead RA-LA is calculated using the first two leads. 12-bit A/D converter does the sampling on each RA-LL and LA-LL channel. The sampling frequency is adjusted from 200 Hz to 1 KHz. Therefore, it produces a data steam, which is at the rate from 4.8Kbps to 24Kbps. A micro-SD card which has 2 GB storage capacity is used for data logging. It has an integrated battery 250 mAh Li-Ion which powers the circuitry[4].

Figure 2. SHIMMER platform

b) Raspberry Pi

Raspberry Pi is a microcomputer developed by a non-profit foundation called Raspberry Pi in the UK. After several overcomes, the first model of Raspberry Pi came around February 2012, with 256 MB RAM. The second version was released with 512 MB RAM. The microcontroller has 17 GPIO pins and other special functions such as two pins for I2C, six pins for SPI and two pins for USART. All 17 pins can be used as either inputs or outputs. Raspberry Pi uses LINUX platform for running codes. By this, the real time signal can be viewed and diagnosed.

Figure 3. Raspberry Pi

Initially, the SHIMMER platform is tied around the body near the chest region using a belt attached to it. In literature very few works explained the ECG acquisition method with wireless transmission based on RF technique[5] [6]. The surface electrodes are connected to the SHIMMER and they are placed at the appropriate position in the chest wall. When the power is turned on, the electrodes pick up the signal from the body and sends it to the amplifier present in it. The acquired and amplified signal isthen transmitted based on ZigBee technique by the MSP430 microcontroller. It converts the analog signal or data collected from the body of the athlete into digital signal. The compression of ECG data before and after the transmission is an important one to design an algorithm which doesnot exceeds the computation power of the SHIMMER's microcontroller [7]. Therefore, it can be easily transmitted using 802.15.4 or ZigBee module. This received ECG data can be stored in the SD card and used for later analysis. During the competitions, the data from the SHIMMER is transmitted to the ZigBee receiver placed near to the court. To get the real time data, the Zigbee receiver collects the data and then transfer it to the Raspberry Pi. Raspberry Pi controller can be programmed using the Python platform. Therefore, the real time signal is acquired during the competitions and viewed through Raspberry Pi. The abnormalities in the ECG wave during the competitions can be easily detected.

III. Results And Discussion

ECG wave acquired and monitored with a sampling frequency of 500Hz. The SHIMMER platform has 12-bit resolution A/D converters. Therefore, the bit rate produced by the two channel ECG module is 12 Kbps. Using lower sampling frequency of 200 Hz with 8-bit samples produces a 3.2 Kbps data stream [8]. By using this technique, the ECG signal quality may be affected but it can be compensated by the receiver using the signal reconstruction technique. ECG data can be processed on the SHIMMER platform by transmitting reports and alerts in case of cardiac arrhythmia [9].

Initially, the functionality of the proposed system was verified using an ECG simulator connected to the SHIMMER.

Then few trials were performed for tuning the system. The data is transmitted from the SHIMMER to the Raspberry Pi through ZigBee module to get the real time ECG data. Few protocols have been changed to get the real time ECG output.

While getting the real time data, synchronization between the transmitter and receiver should be established properly. The block diagram that we have shown above mentions the pathway of the signal. And the results would be established in units of transmission rates. If the ECG wave is observed as abnormal (unlike the normal ECG wave) then there is some sort of problem associated with the health of the person. Even a minimal change in the normal ECG wave can cause this. To validate this system, real time data from the players need to be acquired.

Primary concern of this systemis athletes, the system has to be validated further on Basket Ball and Squash players. So then the observation would be definitely different because of their exercising and playing manner. The novelty of this work is connecting both the SHIMMER and Raspberry Pi for ECG acquisition analysis.

IV. CONCLUSION

Many fatalities and causalities caused mainly in athletes due to over dieting and exercising is the main motivation for this work. This equipment would help the players to take precautionary measures. Not only for athletes but anyone who works out for more than the requirement will face any sort of problem in the heart. So there has to be a routine exercising schedule that they should follow and this whole experimentation explains that. This work proposes a portable equipment which helps athletes to test themselves.Another advantage of this equipment is that it is a real time or real mode monitoring equipment. This work has to be validated with different kinds of athletes for the betterment of their health. In general if athletes exercise up to the recommended level and follow a proper diet as said by the instructor, they have a proper health condition.

REFERENCES

[1] Guyton, A., Hall, E., Textbook of Medical Physiology. 11th Edition, Unit III.

[2] Tortora, G., Derrickson, B., Principles of Anatomy and Physiology. 12th Edition, Unit 20.

[3] Xu Yong, Bi Tingting,Bian Chunhua, Shen Qinghong, Ma Qianli**.** Design of the athlete's electrocardiogram monitoring and evaluation system based on wireless sensor network.

[4] Burns, A., Greene, B., McGrath, M., O'Shea, T., Kuris, B., Ayer, S., Stroiescu, F., and Cionca, V. SHIMMER: A Wireless Sensor Platform for Noninvasive Biomedical Research. IEEE Sensors Journal, 9 (2010), 1527–1534.

[5] Jain, S., Shah, R., Brunette, W., Borriello, G., and Roy, S. Exploiting Mobility for Energy Efficient Data Collection in Wireless Sensor Networks. MONET 11, 3 (2006), 327–339.

[6] Nayebi, A., Sarbazi-Azad, H., and Karlsson, G. Routing, Data Gathering, and Neighbor Discovery in Delay-Tolerant Wireless Sensor Networks. In 23rdIEEE International Symposium on Parallel and Distributed Processing, IPDPS 2009, Rome, Italy, May 23-29, 2009 (2009), IEEE CS, pp. 1–6.

[7] Hossein, M., Nadia, K., and Pierre, V. Real-Time Compressed Sensing-Based Electrocardiogram Compression on Energy Constrained Wireless Body Sensors. In IEEE International Symposium on Circuits and Systems (ISCAS2011) (2011), IEEE CS, pp. 1–4.

[8] Singh, B. N., and Tiwari, A. K. Optimal Selection of Wavelet Basis Function Applied to ECG Signal Denoising. Digital Signal Processing 16, 3 (2006), 275–287.

[9] Madzarov, G., and Dordevic, D. Heartbeat Tracking Application for Mobile Devices – Arrhythmia Recognition Module. In 32nd International Conference on Information Technology Interfaces (ITI2010) (2010), IEEE CS, pp. 585–590**.**