Heart Rate Monitoring using Pulse Oximetry and development of Fitness Application

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***Abstract*—In recent days, there is enormous research going on about bio-medical instrumentation along with medicine. In this day and age, one of the crucial parts of one's health is heartbeat or BPM(Beats Per Minute) and it is very important to maintain the staging of the heart rate in the human body. Previously the heartbeat was measured only in the clinics and the hospitals, but now they have eventually found their way into the applications of the mobiles. There is a necessity to build a precise and very cost effective measuring instrument to ensure the calibration of the heart monitoring system all the time. By exploring the various factors that are influencing the abnormal heart rate of people such as the cognitive decline, the symptoms of anxiety and the depression and obesity we can realize the importance of the workout activities in our day to day life. The workout activities of the people in the current life cycle basically include dancing, walking, running and other similar activities. In order to maintain a good lifestyle, we need to keep track of all our day to day workout activities so that we can assess ourselves. Hence various apps are developed for guiding the people to lead a healthier lifestyle. This paper proposes the continuous measurement of heart rate using MAX30102 interfaced with the QtPi Rio board and development of fitness app for encouraging the fitness activities. key words: bio-medical instrumentation, BPM(Beats Per Minute), heart rate, QtPi Rio board.**

***Index Terms*—component, formatting, style, styling, insert**

I. Introduction

MAX30102 is an electronic device used for measuring the heart rate. It is very essential to continuously monitor the heart rate of the patients and athletes in order to determine the state of the heart. One of the most accurate ways of determining the heart rate is using the Electrocardiography. The measured data set of electrical activity by making use of a cardiograph is termed as Electrocardiogram(ECG). ECG is the most commonly used method to measure the heart rate. The ECG plays an important role in identifying a person's health condition typically focusing on the average heartbeat. This diagnosis is usually done by a cardiologist. [3] The perpetual pumping of blood for every second produces a heartbeat. The atria will contract as the natural pacemaker of the heart i.e. the SA node sends out an electrical signal. This will happen when the blood accumulates in the upper chamber of the heart. This phase is called diastole. When the blood fills the ventricles, the SA node sends the electrical signals through a pathway of cells which makes them contract. This contraction phase is known as systole. There is no way for the blood to flow back since the tricuspid valve and the mitral valve will close as soon as the blood fills inside the heart chamber. The heart rate is measured in terms of beats per minute. It is one of the compelling signs to indicate the health of the body due to any of the physical activity, emotional responses, threats to safety and even when the person is relaxed. The heart rate will consecutively become slower as a person gets older towards adolescence. The difference time in which the pulse reaches normal represents the fitness of health. The app development is mainly based on human mobility patterns and economic conditions. An application should be usually developed based on data analysis. Mobility influences human workout activities. The people who take up the training activities following an app are less prone to diseases with respect to heart rate. The apps also may not require a venue, types of equipment or cost. [1]

The heart rate varies as the body absorbs oxygen and gives out the carbon dioxide during activities like sleep, exercises, etc. In order to diagnose and track the medical conditions of the patient, the medical professionals measure the heart rate continuously. [4]

200 years back, the first heart rate monitoring device was the stethoscope and was invented by Rene Laennec. However, this device lacked accuracy and could not be used to detect the changes that occurred in the heartbeat. At the beginning of the 20th century, first electrocardiograph (ECG) was invented by Willem Einthoven which made a way for graphical recording of the electric activity in the heart. The heart-related problems are usually diagnosed using ECG which is termed to be a non-invasive clinical tool. [6]

The ECG is done by placing the electrodes on the specific parts of the person. The electric signals obtained from the electrodes helps the doctor to learn the irregularities of the cardiogram. This helps to receive the bio-electric events associated with the heart. He explained that in ECG the waveform of the heart will be divided into three parts, i.e. P wave, QRS complex and T wave which varies according to the function of atria and ventricles. [2]

In the paper [3], the heart rate is measured using light and optical sensing sensor which uses the principle of photophelthysmography (PPG) where the blood volume in the

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finger tissue is detected. The fluctuation in the blood can be seen only when the fingertip is placed on the sensor and the signal from the sensor is moved to the controller through serial port communication. Here the controller used is Arduino. The sensor consists of the Infrared LED and IR sensor.

According to the paper [8], the author has tried to develop an economical and affordable system integrated with the mobiles and non-invasive sensors for electrocardiogram activity measurement. However, the non-invasive sensors are effective but receive noise.

HEART RATE MONITORING

In recent days there are different types of wireless heart rate machines are developed. These HR-Ms usually have less reliability and validity uses electrodes for measuring the heart rate by placing the fingers on them. People are able to easily access these wireless devices for measuring heart rate independently during both sympathetic and parasympathetic training.

At the beginning of the development of the wireless heart rate machines, the research was mostly on the heart rate responses from athletes where the change in the heart rate was observed, unlike the submaximal exercises which used be less clear. The change in heart rate also depends on other factors and parameters which influence the heart rate. One of the parameters which the heart rate is being influenced is oxygen uptake.

The oxygen uptake helps to observe even the small variability in each and everyday activities. Other factors which influence the heart rate are physiological parameters such as cardiovascular drift, hydration status, etc, and the environmental factors such as temperature (heat and cold) and altitude.

The heartbeats per unit of a particular time are known as heart rate. In recent days, people are using the fingertip sensor interfaced with the microcontroller which is much more cheaper and easy to use and even easier to understand.

HARDWARE IMPLEMENTATION

The sensor is interfaced with the QTPI Rio board. This board incorporates Atmeg328 processor consisting of six sensor ports where the sensor can be easily connected to the board by using an RJ cable. The QTPI Rio board based on the AVR RISC architecture is a low-power CMOS 8-bit microcontroller which has a throughput of 1MIPS per MHz The heart rate sensor is connected to the QTPI Rio board to the port1 through the RJ11 cable which has I2C interface.

The features of QTPI Rio are :

- Single clock execution cycle.
- 32Kbytes flash memory.
- 2KB internal SRAM.
- Two 8bit timer/counter and one 16bit timer/counter.
- 6 PWM channels.
- Brownout detection and Power-On-Reset.
- SPI, I2c, ADC, and USART.

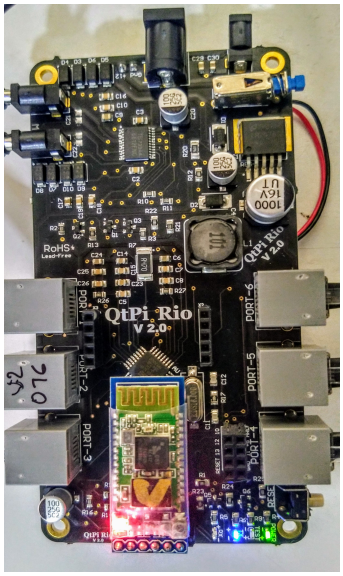

Fig. 1. QtPi Rio Board

The MAX30102 sensor is a pulse oximetry module which consists of the photodetectors, optical elements, and internal LEDs. It is a cost proficient IC that is used to measure the electrical pulse action of our heart. It operates on the 1.8V power supply and can be interfaced with the microcontrollers using standard I2C communication. This sensor works on sample rate and high SNR. This sensor can be basically used on any wearable fitness assistant devices.

Fig. 2. IC MAX30102

This paper explains the implementation of the heart monitoring system for real-time analysis of a person and his heart rhythmic condition based on QtPi Rio board microcontroller and MAX30102 heartbeat sensor and the development of the fitness application. The pulse oximetry sensor is interfaced with QtPi Rio through I2C communication. The average heartbeat per minute of an adult will be 60-100. Fig:3 shows the average heartbeat values and raw IR data values. The principle of IR data through the skin with respect to time is shown in Fig:4. The photo detector present in the sensor collects the IR Raw data and sends to the PC using I2C protocol.

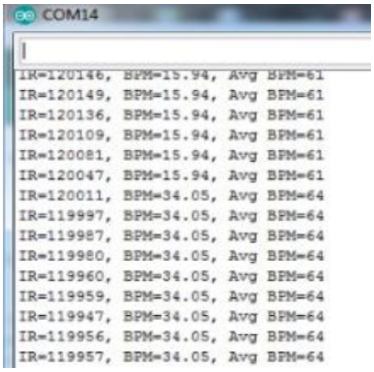

Fig. 3. Average BPM O/P

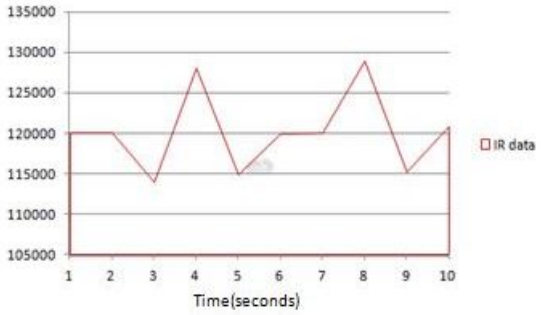

Fig. 4. Raw IR Data

The application which is developed as represented in Fig:5, uses the accelerometer of the phone to count the number of steps. The fitness app is developed to keep track of the activities of the people. The smart application motivates people to maintain well-being condition. This application counts the leg movement and the hand movement of an individual. Hence even the simple exercises can also be done and monitored.

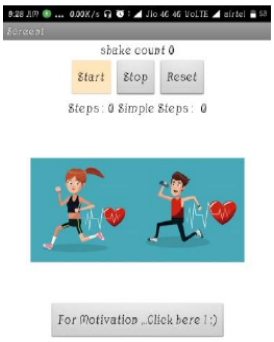

Fig. 5. Average BPM O/P

CONCLUSION

These papers show that people can diagnose themselves individually without any help and also motivates them to keep themselves fit. The heart rate monitoring system is developed in real time where the person can judge the change in the average BPM. The IC MAX30102 is designed in a unique way such that the sensor can be connected to the sensor port of the microcontroller as shown in Fig:1 using only RJ cable. This system also gives an advantage of portability where a person can check the heart rate from anywhere and anytime in the form of wearable devices, unlike the ECG signal diagnosis. The app is developed for people to access their fitness levels based on their fitness activities. The mobility factors of the human day to day activities can be observed in the app.

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