Pulse Rate Monitoring Embedded System during Indoor Exercises Using Microcontroller

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Abstract: In the current paper we have described the design, testing and result data of a low cost heart beat measuring device. The proposed model works on the properties of optics. Our model is non-invasive in nature and able to measure heart rate of any individual during different physical activities. We have also developed a better algorithm for measuring heart beat rate at a fixed interval of 5 seconds. The heart beat is counted by a specific microcontroller that displays the heart rate data on an LCD continuously. We have also measured the heart beat rate of an individual running on the trademill at variable speed and compared the result with our model.

Keywords: pulse rate, heartbeat, microcontroller, trademill, Photoplethysmography, Electrocardiography.

I. INTRODUCTION

Heart beat rate basically stands for cardiac cycle done by the heart per minute or beats per minute(bpm). The average heart beat of a healthy individual lie in the range of 60-100 bpm. When the bpm drops below 60 bpm this leads to an abnormality known as “Bradycardia” and when it rises above 100 bpm it is called “Tachycardia”. The diseases related to heart mainly occurs due to age, increasing blood sugar level, family history related to cardiac diseases, lack of physical activity, social change, drug addiction etc. One can be aware of diseases related to heart by checking its heart beat rate regularly. Here for displaying heart beat we have used smartphone which connects to the device via Bluetooth.[1]

II. WORKING PRINCIPLE

In markets, a wide variety of handheld, portable devices are available which can be used to obtain and check heart beat regularly by ourselves. Nowadays, various smartphones are also capable of measuring heart rate using some sensor preinstalled on the smartphone itself. To obtain heart beat there are preferably two techniques i.e. Electrocardiography (ECG) and Photoplethysmography (PPG) [2]. ECG employs two or mote electrodes for determining heart beat rate from electrical changes that occurs in our body. It is primarily used for medical related purpose. PPG employs optical communications techniques for obtaining heart beat rate. The signal for ppg can be acquired from our fingertips, earlobe etc. and by using a data processing system we can process, calculate and display the heart beat rate value on any displaying equipment or device.[3]

III. PREVIOUS WORK

An author proposed a HEART BEAT RATE monitoring system using “signal processing and Artificial Neural Network (ANN)” techniques to detect and classify different cardiac problems. He used real time processing, intelligence, cost effectiveness and competent use of the ECG diagnostic system. He suggested the use of diagnostic medicinal systems remotely for diagnosing at home [4].

Another author described a nonlinear input-output relationship between the trademill speed and the HEART BEAT RATE (HBR). They employed a controller to regulate the HBR with well-defined input signal which is related to the predefined HBR value [5].

Another author had proposed a microcontroller based HBR monitor using fingertip sensors. The microcontroller acquires the signal and removes the zero-crossing problems of the digital signal which is obtained by Fourier transformation. He also employed one audible alarm to indicate the HBR status [6].

IV. OBJECTIVE AND METHODOLOGY

In this paper, a methodology is proposed which is based on Photoplethysmography light reflection technique for analyzing and calculating heart beat rate using a light emitting diode emitting infrared signals. In this method change in the intensity of light is measured which is sensed by the infrared sensor. The basic mechanism involves light reflected back which varies with the heartbeat [7]. The reflected signal intensity varies person to person depending upon his health condition. For eg: a healthy person will have heart rate lower than an unhealthy person. This phenomenon is analyzed and on the basis of this analyzation heart rate is calculated.

V. HARDWARE SETUP

The propose model is illustrated in the block diagram as sown in Fig.1.

Fig.1. Functional block diagram of proposed system
In this system an optical sensor is used to gather Photoplethysmography or PPG pulse from the fingertips. The small and compact integrated circuit comprises of infrared light emitter and a phototransistor. But the detected signal was very weak and noisy. It was due to other sources of light, power supply noise etc. To remove the undesirable noise a low pass filter with cut off frequency 2.4 hZ is employed. Then the signal is amplified by using an amplifier of gain 100. Here we have used a double stage amplifier that has an overall gain in the range of 104. Then this amplified signal is converted to digital form using comparator. The operation IC used by us is IC 741 which has been used to design the amplifier and the comparator. The sensor and the amplifier hardware connection are illustrated in Fig. 2.

For analyzing and deriving heart beat rate wherein timer 1 calculates pulse and timer 0 generates the delay. The HBR value per minute is obtained by multiply the derived result by twelve. In this system Digital Phosphor Oscilloscope (DPO, Model: Tektronix, 4102B-L) and LCD (JHD162A) is used. The proposed system also developed an algorithm primarily for 5 sec duration to calculate the PPG pulse received from the fingertip during this interval. This system uses a manual trademill for heart rate monitoring during physical activities like running and walking as shown in Fig. 5.

The trademill comprises of 5 display unit each separate for displaying time, speed, calorie, pulse and distance while we walk or run on the trademill as shown in Fig. 6.
VI. ALGORITHM EXPLANATION
Basic step our model follows are as follows:
Step 1: Start
Step 2: Initialization
Step 3: Set timer 1 high
Step 4: 5sec delay generation
Step 5: Start timing and counting
Step 6: Stop counting after 5sec
Step 7: Multiply the result by 12
Step 8: Conversion of result from Hexadecimal to Decimal and then from Decimal to ASCII value
Step 9: Display the Output
Step 10: Repeat the steps again

VII. RESULT AND DISCUSSION
In the proposed system the reading data is taken using our model device. The graph of Photoplethysmography signal v/s comparator output is displayed in Fig.7.

Fig.7. Output of sensor taken from DPO
The heart beat rate measured at variable speed using trademill and the proposed model are described in Table 1.

Table I: HBR measured at different speed

| SL. No. | SPEED (Km/HR) | HBR (Treadmill) | HBR (Proposed device) |
|---------|---------------|-----------------|-----------------------|
| 1       | 1.2           | 62              | 60                    |
| 2       | 1.8           | 65              | 60                    |
| 3       | 2.5           | 70              | 72                    |
| 4       | 2.8           | 72              | 72                    |
| 5       | 3             | 73              | 84                    |
| 6       | 3.5           | 75              | 84                    |
| 7       | 4             | 78              | 84                    |
| 8       | 4.2           | 80              | 84                    |
| 9       | 4.5           | 85              | 96                    |
| 10      | 5             | 90              | 96                    |