Low-Cost Portable Heart Rate Monitoring Based on Photoplethysmography and Decision Tree

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Abstract. Heart disease is caused by a cardiac function which does not work optimally. This illness can be detected by sensing a pulse that is defined as the rhythm of the heartbeat. Some researchers have conducted a study to determine and monitor heart rate. Researches resulted in very expensive and not portable tools. Therefore, this paper examines portable heart rate monitoring with photoplethysmography method and decision tree algorithm. The photoplethysmography method is an optical technique that is cheap and simple that can be used to detect changes in blood volume in the microvascular network. The method modified on the transmitter and receiver sensors. The decision tree algorithm is used to make decisions for digital data of retrieval heart rate. With the decision tree algorithm obtained a normal heart, Bradycardia, and Tachycardia. The method and algorithm result in a much cheaper tool which can detect heart rate which later is categorized into the normal heart, Bradycardia, or Tachycardia.

Keyword:Bradycardia, Tachycardia, Heart Rate, photoplethysmography

INTRODUCTION

The heart is a vital organ of the human body that serves to pump and circulate blood containing nutrients food and oxygen to all parts of the body [1]. When the heart is impaired, it will cause several diseases such as hypertension, stroke, myocardial infarction, cerebrovascular, etc. [1], [2].

Heart rate is a heartbeat rhythm that can be sensed on the surface of the skin at certain places [3]. It is the easiest way to determine a person's heart rate and generally equal to the frequency of the heartbeat.

Several researchers have conducted studies in counting heart rate by using ECG [4], [5]. Lagido et al. [3] used a smartphone camera to count it while Guo-cheng and Hong-yang [6] developed the research by using light sensors to detect heart rate and calculate heart rate by using iOS platform.

To overcome the problem, several researchers have conducted research by applying sound theory to detect heart beats such as Coiado et al. [7] who used ultrasound and Wang [8] who used a microphone. The later researcher processed heart rate data by using a smartphone.

Other researchers used photoplethysmography method which is a method using light sensors [9] - [14] to detect heart rate. Infrared and photo sensors are used by Ramlee et al. [9] and Rahman et al. [10] to detect it. Some other researchers compare the performance of led Red, Green, and Blue to detect heartbeat such as Lee et al. [11]. Photodetector sensors are used by Fukushima et al. [12], Miah et al. [13], and Izneid et al. [14] who used photoplethysmography theory to detect heart rate.

Cardiac monitoring is very important to diagnose the health condition of a person. This study presented in this paper uses a light sensor to detect heart rate. The sensor used in this study using a photodiode as the receiver and infrared as the transmitter. The method used in this research is the development of the theory of photoplethysmography

RESEARCH METHOD

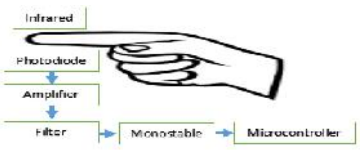

FIGURE 1. Heart rate monitoring diagram block

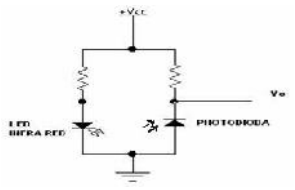

FIGURE 2. Design of Infrared and photodiode circuit

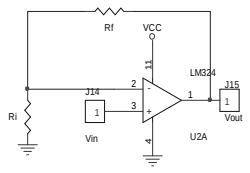

FIGURE 3. Design of a non-inverting amplifier circuit

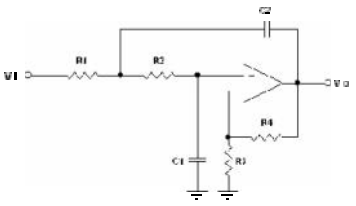

FIGURE 4. Design of low pass filter Butterworth circuit

RESEARCH METHOD

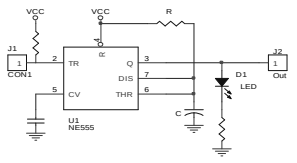

FIGURE 5. Monostable circuit design

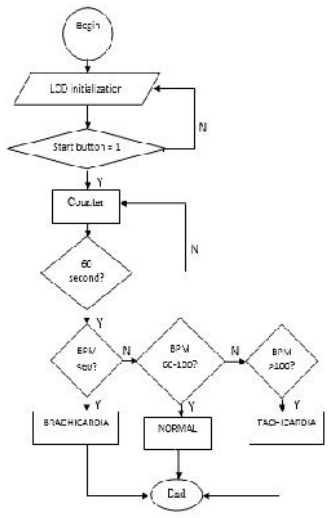

FIGURE 6. Flowchart of decision tree algorithm

DISCUSSION AND RESULTS

Some samples were taken to prove that the method was applied accordingly in this experiment. Data retrieval was conducted by using Fig. 7. In the figure, it can be seen that the tool consists of a processor master and finger sensor. Heart rate data is obtained by placing a fingertip in the sensor as shown in Fig. 7b, then by pressing the power button to on position, LED indicator light turns on as well as the pulse indicator light in tune with the pulse. Once the loading is completed, the tool starts to count pulses up to 60 seconds. The numbers of BPM then appear on the LCD, and so it can be categorized as Bradycardia, Normal, or Tachycardia.

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GURE 7. Heart rate specifications

The experiment was conducted by taking samples of children, young people and adults with ages between 1 to 30 years. The experimental data are in Table 1 which shows the relationship between pulses with a person's age. The experiment which was conducted to adults aged over 18 years shows a normal BPM value ranging from 60 - 100.

TABLE 1. Capturing pulse based on person's age

Age	BPM
1 – 2	110
2 – 6	105
6 – 10	95
10 – 14	85
14 – 18	82
> 18	60-100

DISCUSSION AND RESULTS

TABLE 2. Capturing pulse based on person's age

No	Name	Age	Weight	Relaxed data	Exhausted run data
1	Wi	29	45	78	83
2	Jo	19	64	77	80
3	Di	30	50	79	89
4	Bu	25	90	80	102
5	Li	33	42	75	79
6	Pa	35	100	102	110
7	Hu	45	56	70	89
8	Wa	43	40	78	89

The second data sampling for eight adults conducted during a relaxed state and after running. The experiment is shown in Table 2. In the table, it can be seen that there are some who have abnormal heart pulse. Abnormal beats are those that less than 60 or more than 100. From the table, it appears that Pa suffers Tachycardia because when he is in a relaxed state or after he runs, he has a pulse rate above 100. Bu also has a symptom of Tachycardia because when he is in a relaxed state, the pulse is still normal but after he runs the pulse goes above 100

CONCLUSION

The photodiode and infrared detection sensors can be used as pulse counters. With photoplethysmography method, the output voltage of the photodiode is very small, thus, it requires an amplifier circuit to strengthen the signal. In addition, the signal has noise at low frequencies requiring a low pass filter Butterworth to remove it. In order to be processed by a microcontroller, a signal is fed into a monostable circuit to obtain noiseless square wave which is then changed into a pulse. By using decision tree algorithm, the rhythm of the heart is divided into three categories, namely Tachycardia means that the heart rate is over 100 beats/min, Bradycardia means that heart rate is less than 60 beats/min and Normal means that heart rate is between 60-100 times/min.

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