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The Real-Time Vital Sign Monitor for Heart Rate and SPO_2 Parameter Using Internet of Things Technology

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Abstract. Recently, the internet of thing (IOT) has been growing rapidly in many fields including in the biomedical vital sign monitoring of a human. Heart rate and SPO2 are vital sign parameters for human life. Those parameters needed to be observed for patients in an emergency situation. In patient care at hospitals, doctors need to monitor the patients' heart rate and SPO2 parameters continuously. Therefore, the objective of this study was to develop the heart rate and SPO2 parameters based on IOT technology. The heart rate and SPO2 parameters were detected using a finger sensor and an oximeter sensor, respectively. The digital data from those sensors, further, was processed using ESP8266 microcontroller. By using a built-in Wi-Fi module in ESP8266, the vital sign was sent to the user wirelessly to handphone or central monitor using Think Speak application, remotely. In this experiment, the sensors were placed on the finger while the patient was in the standing, lying or sitting position. In the same position, the parameters were acquired for ten times. Some analyses were conducted to find the accuracy of the measurement. The results showed that the uncertainty were 0.26 and 0.04 for heart rate and SPO2, respectively. Based on the medical standard calibration (<3%), those parameters are feasible to be used in the medical system measurement. The T-test analysis statistics for one independent sample was performed to obtain a significant difference among the data. The p-values were 0.118 and 0.000 for heart rate and SpO2, respectively. Finally, this study suggested that the IOT system was able to monitor the parameters effectively.

1. Introduction

Exercise is an activity that cannot be separated from health, the more people diligently doing exercise, the healthier their body and the stronger their muscles would be [1]. When doing exercise, the cardiovascular system function will experience an increase and decrease in pulse rate followed by an increase in stroke content, lung capacity and lactic acid accumulation, collateral blood vessels, HDL cholesterol and also experience decrease in Atherosclerosis [2]. In resting state the heart beats 70 times/minute. When doing many movement the heartbeat can reach 150 times/minute with a pump power of 20-25 liters of blood/minute [3]. Cardiac output is the volume of blood pumped by each ventricle per minute. While the normal speed of the heart rate is the amount of beat every minute, in adults, it is 60-80 per minute. According to Nutrition Guidelines for Sports Achievement, the heart rate can be calculated in a way namely cardiac output = heart rate x stroke volume, for example 70 beats/minute x 70 ml / pulse = 4,900 ml/minute or 5 liters/minute (average volume of 70 ml/pulse) [2].

With the increase in a person's physical activity, the need for blood containing oxygen will be even greater. The heart will fulfill the need for oxygen by increasing the blood flow. This will also be responded by the blood vessels by widening the diameter of the blood vessels so that it will have an impact on the individual's blood pressure. When this process takes place, the condition of the blood will increasingly thicken and inhibit blood circulation in transporting digested food and oxygen throughout the body. The role of body fluids (water) is as balancer or blood thinner so that the blood is normal and can circulate the extracts of food and oxygen throughout the body [2]. To determine the speed of a person's pulse, it can be done by knowing the pulse rate by calculating the sudden changes in pressure. This pressure are propagated as waves on the blood wall while measurements can be made on carotid artery (neck area), located in the neck below the ear lobe, where there is a carotid artery between the trachea and the sternocleidomastoid muscle that is often used for babies in cases of cardiac arrest and for monitoring blood circulation. The frequency of the human heart rate varies depends on many factors that influencing it during normal activities. The radial artery (wrist) is located along the radial bone. It is more easily palpated above the wrist on the side of the thumb relatively easy and is often used routinely. BPM or Heart Rate is a representation of the pulse per unit time of an object. Usually, an adult's heart beats 60 to 100 times per minute in resting conditions. If the heart rate exceeds 100 beats per minute, the person is indicated to have Tachycardia heart abnormalities. On the other hand, if the heart rate is less than 60 beats per minute, the person is indicated to have a Bradycardia heart disorder especially if accompanied by other symptoms such as dizziness, shortness of breath or frequent fainting.

Heart Rate or BPM (Beat per Minute) and Oxygen Monitoring is continuous monitoring of a patient's condition that helps medical staff and paramedics in monitoring the progress of the patient's condition [4]. In general, monitoring of BPM and Oxygen can also be done non-invasively by practitioners and the general public by using finger sensors namely photodiode sensors and infrared clipped to the index finger of the hand. In designing the tool by using a sensor oximeter, oxygen level reading can be done easily, but with advances in technology in the field of informatics, the development of Internet of Things (IoT) – it will be much easier to do[5]. In a previous study, detection of conventional heart rate signals still found many obstacles in analyzing, so that by applying this application it would be easier for everyone to analyze the results of data recording in real time during sports activities. The benefits of doing adequate and regular exercise have been widely informed in various health articles, popular articles, and health journals, exercise can prevent obesity, diabetes mellitus, hyperlipidemia, stroke, and hypertension. In their research in Belgium concluded that aerobic exercise can be applied as management of hypertension not only for prevention. Still, in the same study, it was also mentioned that blood fats can be reduced by doing exercise, especially aerobics. Blood fat is what will cause atherosclerosis later if the level is high.[6]

This study aimed to analyze the effectiveness of heart rate (BPM) and blood oxygen level (SPO2) monitoring based on Internet of Things (IoT). The use of computers in the future can dominate human work and defeat human computing capabilities such as controlling electronic equipment remotely. Internet of things (IoT) is designed to connect astronomical numbers of ordinary and everyday objects to the Internet and consequently expand the Internet into the human physical world. This device is usually limited to resources, which have low computing and storage capabilities and are battery-powered [7]. In the coming years, the IoT is expected to bridge diverse technologies to enable new applications by connecting physical objects together in support of intelligent decision making [8].

2. Materials and Methods

2.1. Model Design

Finger sensor and oximeter sensor send analog data to Node MCU ESP8266 via Arduino [9]. From this Arduino module, the input will be processed into data. Furthermore, NoteMCU ESP8266 from the module receives data from Arduino in the form of Wi-Fi data. [10]. After connected with Wi-Fi, this data will be sent into smartphone media through an application to monitor the results, the data update is carried out every 5 seconds.[11]

2.2. *Type of Research*

This research is experimental research with the design of one sample one group. The population and samples in this study were students majoring Electromedical Engineering. Each sample underwent ten treatments. The dependent variable in this study is the description of heart rate (BPM) signals and oxygen levels in the blood. The independent variable is aerobic exercise. The materials and equipment used in this study were: a) stopwatch, time measurement tool, b) module for designing heartbeat (BPM) and oxygen levels in the blood (SPO2) devices, c) smartphones as media to monitor the data that were then processed by using Excel and displayed in graphical form per 30 seconds.

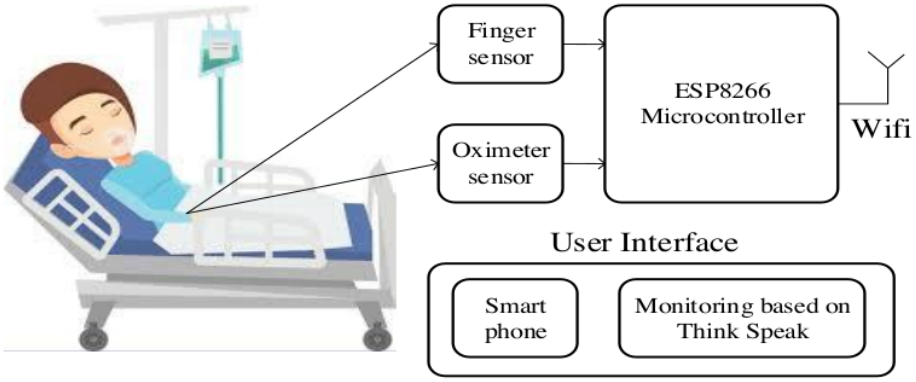

Figure 1. The Experimental Setup on the Development of IOT System for Heart Rate and SPO2 Parameters Monitoring

2.3. *Data Acquisition and Processing Techniques*

Data retrieval was done through some stages, namely: 1) Retrieval of Data, as follows: a. attaches the index finger to the sensor b. data will be recorded and monitored in the Thing Speak application on Android c. then the data is downloaded on the application on the PC. 2). Data Analysis, the data recorded on the device will be transferred through Wifi media through the IoT web by using the Thing Speak application on the smartphone. From the Thing Speak data web, the data can be downloaded with the excel data extension (.cvs). The results of the data on the web on thing speak application can then be monitored in real time in accordance with the amount of value that is on the sensor readings on the equipment.[8]

3. Result and Discussion

3.1. *Statistic Analysis*

The statistic test was done to compare the data tools with the standard data. The aim was to determine the level of significance of the data from the design of the tool with the standard value data. The results of the independent T-Test on the value of the heart rate (BPM) of 10 samples obtained a significance level of $\alpha = 0.118$ (> 5%) so that, statistically, there was a difference between the value of the heart rate (BPM) module and the value standard heart rate BPM. According to the calibration standard for differences, values <5% is considered close to the threshold, which is obtained by measuring the heart rate (BPM), average = 64.8, the standard deviation value was 2.84 and the uncertainty value was = 0.28. Furthermore, the measurement of SpO2 level obtained an average of 95, the standard deviation was 0.44 and the uncertainty value = 0.04. The results of the Independent statistical T-test for SpO2 level obtained a significant value of $\alpha = 0.000$ (<5%) so that it can be said that there was no difference between the

value data from the Design Module and the standard value data, the result of the data monitoring can be seen in the table below

Table 1. Measurement of Heart Rate (BPM) and SPO_2 using the design

Time of Measurement (minute)	1	2	3	4	5	6	7	8	9	10	Mean	SD
Heart Rate (BPM)	64	64	65	63	66	64	62	67	66	67	64.8	1.6
SPo2 (%)	94	95	95	95	96	95	94	96	95	95	95	0.6

Table 2. Measurement of Heart Rate (BPM) and SPO_2 using a calibrator

Time of Measurement (minute)	1	2	3	4	5	6	7	8	9	10	Mean	SD
Heart Rate (BPM)	67	65	64	66	66	65	65	66	65	65	65.4	0.84
SPo2 (%)	96	97	97	97	96	96	96	95	97	97	96.4	0.69

3.2. Test Equipment

Test equipment was grouped into two types of measurements, namely determining the value of the heart rate (BPM) and oxygen level in the blood taken from the Thing Speak application data. The result obtained can be seen in the graph below [6].

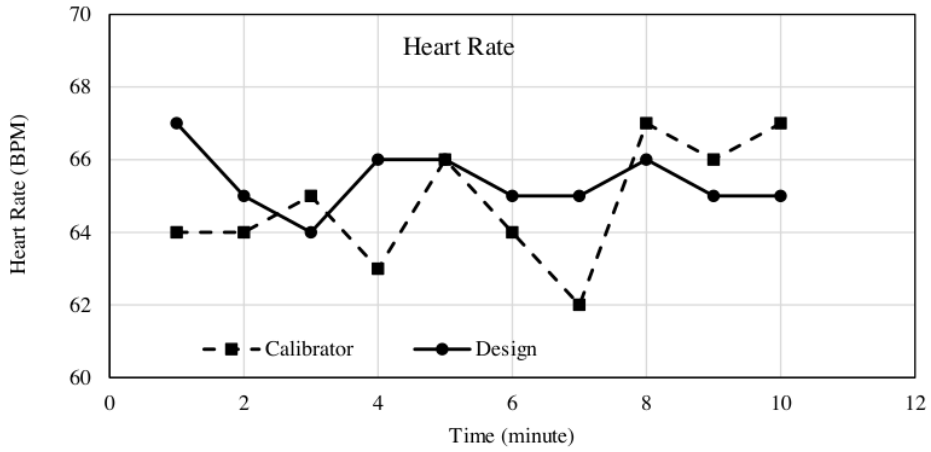

Figure 2. Result of heart rate (BPM) monitoring when subject perform activity

The result of the heart rate (BPM) monitoring of the equipment was 62.5, the standard deviation was 5.7, and the standard error was 1.8. The average result of the standard BPM was 65.4, the standard deviation was 0.84, and the standard error was 0.26. The data collection obtained from measuring the value of oxygen in the blood (SPO2) can be seen in the graph below.

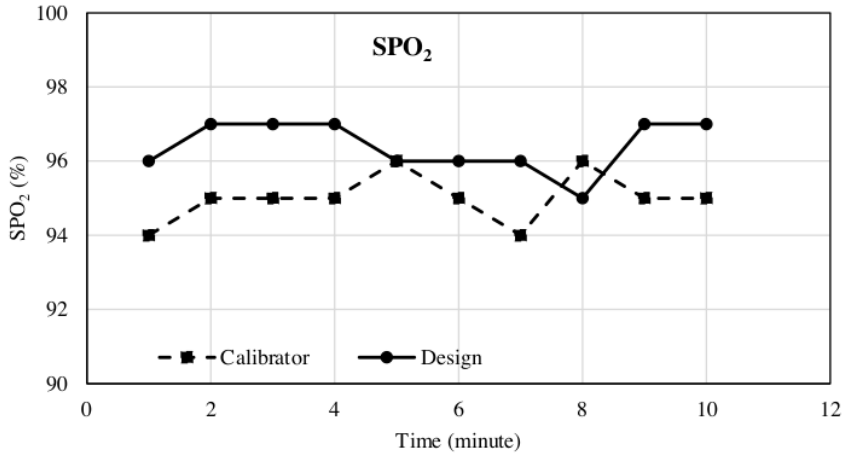

FIGURE 3. Result of Monitoring SPO_2 Level When Doing Activity

The average result of monitoring SPO_2 level on the equipment was 95.1, the standard deviation was 0.56 and the standard error was 0.17. The result of the standard SPO_2 equipment obtained was 96.4, the standard deviation was 0.69, and the standard error was 0.2

4. Conclusion

The results of this study can be summarized as follows: 1) the design of the heart rate (BPM) monitoring and SPO_2 level can be used on subject to monitor the BPM and SPO_2 parameters, 2). the monitoring of those parameters can be done by using the IoT system using ThingSpeak application and it can run normally with a 1-minute period to read on a smartphone. Over all results showed that the design is feasible to be used at home or medical clinics. The researcher suggested and recommended to develop an application on equipment that can be used for multi-modal monitoring.

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