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Development of heartbeat anomaly and hypoxemia monitoring system based on MySQL and Telegram

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Abstract

Everyone needs a good health condition for making productivity. Health conditions can be shown by the performance of the organs body such as the heart. The heart that cannot work properly has a chance of developing cardiovascular disease. Cardiovascular disease is one of the diseases with the highest death rate in world because it has a high mortality rate. Meanwhile, this disease also becomes the highest health case in Indonesia, so it has become a big issue in the medical community. A monitoring device for detecting heart rate anomalies and symptoms of hypoxemia based on MySQL and Telegram is built into this research to determine the state of the heart on mobile. This device consists of MAX30100 for reading pulse and Oxygen rate in the blood, and NodeMCU ESP 8266 for processing data and sending it to the local web server and Telegram. This device was compared with an oximeter made by Mixio for testing the overall system. The result has a little difference of around 0.85% for beat per minute (BPM) error and 0.89% for Oxygen saturation (SpO2). Meanwhile, the data transferred from NodeMCU ESP 8266 to Telegram has a 97% success rate from 100 tests.

Keywords

Heartbeat anomaly, Hypoxemia, Monitoring system

Introduction

Health represents the rating capability of the body to do general tasks. World Health Organization (WHO) explains that good health is a commitment to physical, psychological, and social well-being beyond illness and injury [1]. People's lifestyle can influence their health condition. Some no-good lifestyles are too much eating junk food and smoking cigarettes. Those can affect their heart performance and worsen. In 2000, the mortality caused by cardiovascular disease is 17.90 million people [2]. Cardiovascular disease is one of the highest death rates in Indonesia. Data from Riset Kesehatan Dasar in 2022 shows 15.49 million cardiovascular disease cases [3]. This number increase in recent years which can be seen in Figure 1 [3][4][5]. Cardiovascular disease consists of several types, such as coronary heart disease, rheumatic heart disease, and Endocarditis [6].

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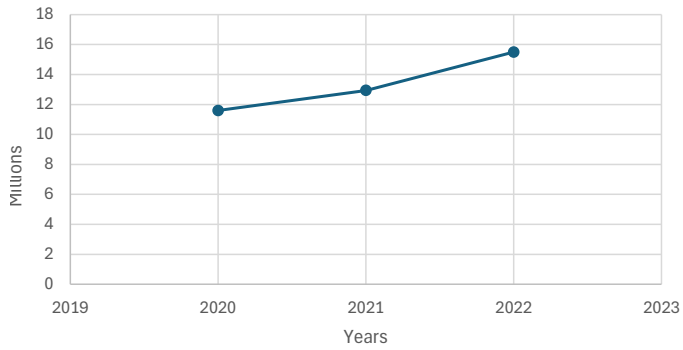

Figure 1. The graphic of cardiovascular disease case in Indonesia

In the half of the 21st century, the Coronavirus disease 2019 (Covid-19) pandemic struck out. This virus, COVID-19, can contaminate the heart and increase the chance of developing cardiovascular disease. Analysis of COVID-19 cases in Hubei Province shows that 7.3% of 137 people have heart palpitations [7]. Heart palpitation is a condition when the heart has an irregular beat rate. It can be called a heartbeat anomaly. An oximeter device can detect this anomaly. An oximeter is a device to measure pulse and oxygen levels in blood. Pulse can represent heartbeat because heart contraction increases blood pressure and pulse [8]. The application of an oximeter is helpful for hypoxemia disease. Hypoxemia is a condition of decreasing oxygen levels in blood below normal [9]. Oxygen is needed for organs in the body to perform.

Some research was done by combining an oximeter with and without the Internet of Things (IoT). One of the research projects is using MAX30100 as a measuring Oxygen device. It has an error of 0.0123% compared to an oximeter with brand [10]. There is the same research method as the research before, but it can be monitored by the Internet of Things (IoT) system. Its result shows error with less than 3% for Oxygen saturation and 1.03% for heart rate [11]. Meanwhile, the research using NodeMCU is developing MAX30100 with Telegram as communication data [12] and a website from platform IOT Blink [13]. In the research [12], the result has an error of approximately 1.7% for all testing. The research [13] and [14] has an error below 0.9% . However, they do not have a database for saving the reading.

The condition around and that research is giving a push for developing the oximeter device. In this research, the designed oximeter can track the heartbeat and Oxygen levels based on MySQL which every reading will be sent to it. This feature helps the doctor to check the patient's condition around the time, especially patients who are working in the field. In addition to MySQL, the reading from the designed oximeter is also sent to Telegram as a notification for the employer's director. The condition being monitored:

The heartbeat anomaly

The heart is the body's organ consisting of muscle and cavity [15]. Its location is in the left part of the chest cavity and below the lung protected by the sternum and the ribs. The size of a heart is approximately the size of an adult's fist [16]. The heart's functions

are pumping blood to distribute nutrition and Oxygen in the body. Arteries and veins transmit pulse when blood is pumped out from the heart. The pulse is felt in front of the wrist and at the tip of the finger where the radial artery is located [15]. Electro Cardio Graph (ECG) is generally a method for determining the heartbeat. Moreover, the simplest way to determine the heartbeat is to use a stethoscope and a stopwatch. The normal standard of heartbeat can be seen in Table 1.

A heartbeat that has lower or higher rates than normal can be called a heartbeat anomaly. This condition happens because of the disorders in the body or the increase in the need for Oxygen after doing hard work. The heartbeat anomaly is grouped by tachycardia and bradycardia [17]. Tachycardia is a condition where the heart rate is higher than normal [18]. Tachycardia emerges because of the condition body after exercise or because of the body's response to disease, stress, and trauma. Meanwhile, bradycardia is the opposite of tachycardia, a lower heartbeat condition [18]. Normally, bradycardia appears in sleeping people or older people. However, it can arise from drug people or overdose smokers and alcohol drinkers [19].

Table 1. The standard of heartbeat [18]

Age	Resting Heart Rate Range (bpm)
0-1 month	70-180
2-11 month	80-160
1-2 years	80-130
3-4 years	75-140
5-6 years	70-130
7-9 years	70-120
≥10 years	60-100
Well-trained athlete	40-60

The Hypoxemia

In every normal body, the normal level of Oxygen is about 95% or higher [18]. The levels of oxygen in blood circulation lower than that can cause hypoxemia. Hypoxemia happens because of impaired oxygenation, anemia, or decreased hemoglobin affinity to Oxygen [20]. Some diseases or medical conditions, such as COVID-19, acute respiratory distress syndrome (ARDS), and asthma, can trigger hypoxemia

Methods

This research was done in the Electrical Laboratory of Universitas Balikpapan for four months. In this research, the researchers use the prototype method and observation method. The prototype method is making the designed oximeter. Meanwhile, the observation method is comparing the designed oximeter with the oximeter made by Mixio. Furthermore, the heartbeat and Oxygen levels results were compared with data reference to conclude the volunteer's health condition.

The designed oximeter

There are three processes to make the designed oximeter. The first process is making the circuit schematic that connects the microcontroller, sensor, actuator, power supply,

and the other electronic components shown in Table 2 with Fritzing software. This process is done to analyze the circuit and to map the components. The circuit schema is shown in Figure 2. The second process is constructing the printed circuit board (PCB). The PCB is designed with Microsoft Office Visio 2007. After that, the design is printed in the plain PCB that is dissolved in Ferric Chloride Liquid (FeCl3) afterward. The last process is placing the PCB and the other components into the box as the body of the designed oximeter. The final design can be seen in Figure 3.

Table 2. The electronic components

No.	Component
1	NodeMCU ESP8266
2	MAX30100
3	Power supply adaptor 5V 2A
4	Universal Serial Bus (USB) cable micro type
5	Cable
6	Cable connector
7	Liquid Crystal Display (LCD) 16*12 with Inter-Integrated Circuit (I2C)
8	Switch
9	Buzzer

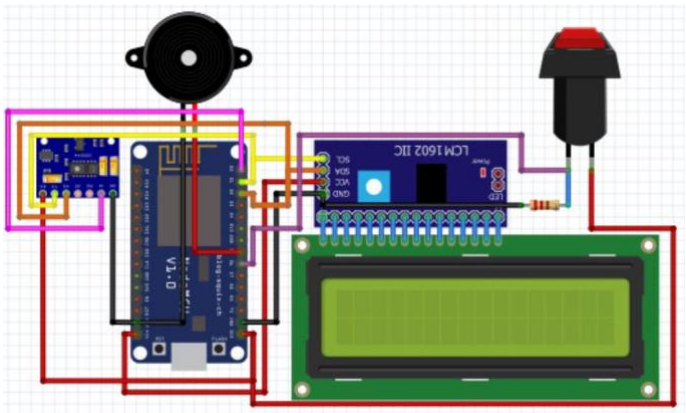

Figure 2. The circuit schematic

Figure 3. The device installation

The design of data transfer in the system

Figure 4 shows the reading data transfer process. There are two types of reading data transfer in this system. They are data transfer to Liquid Crystal Display (LCD) 16*2 and data transfer to local web server. The data transfer to LCD 16*2 is executed as the switch

is off. When the switch is on, the data is transferred both to LCD 16 and the local web server. This transfer process needs an administrator to insert the user data into the database of MySQL and Telegram.

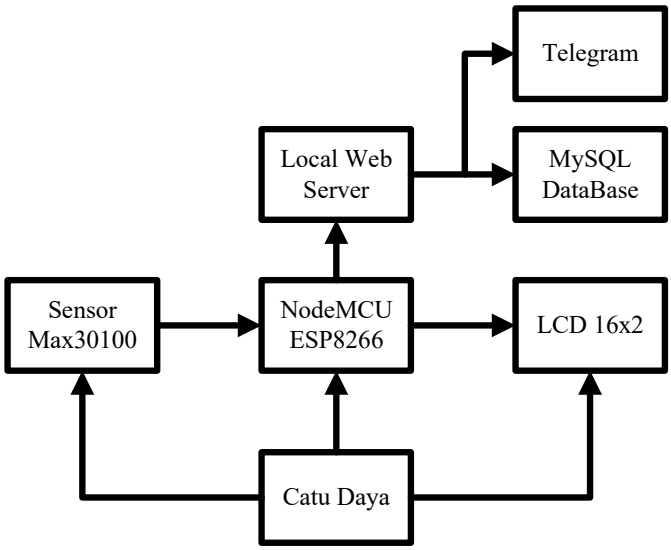

Figure 4. The diagram of sensor reading data transfer

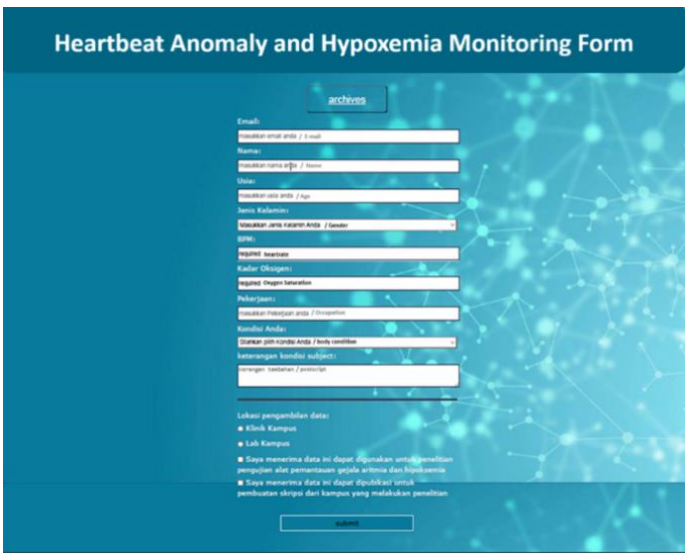

Figure 5. The appearance of design web server

The making of template of the local web server in this research uses Notepad++ with Hypertext Markup Language (HTML) and Hypertext Preprocessor (PHP) language programming. Figure 5 shows the appearance of the web server. In Figure 5, the researcher, as administrator, inserts and saves the user data. The saved data is gathered in a database that is neatly arranged in the table as shown in Figure 6. That table can be accessed by administrator to analyze data. Furthermore, the data is sent to Telegram as notification of the reading. The content of the notification is represented in Figure 7.

	id	Nama	BPM	SpO2	Email	Lokasi_Pengambilan_Data	Umur
Edit Copy Delete	94	Relawan 1	86.33	97%	relawan1@gmail.com	Lab Kampus	24
Edit Copy Delete	96	Relawan 1	93.64	98%	relawan1@gmail.com	Lab Kampus	24
Edit Copy Delete	97	Relawan 1	94.74	99%	relawan1@gmail.com	Lab Kampus	24
Edit Copy Delete	98	Relawan 1	96.58	98%	relawan1@gmail.com	Lab Kampus	24
Edit Copy Delete	99	Relawan 1	97.85	98%	relawan1@gmail.com	Lab Kampus	24
Edit Copy Delete	100	Relawan 1	99.68	98%	relawan1@gmail.com	Lab Kampus	24
Edit Copy Delete	101	Relawan 1	100.86	98%	relawan1@gmail.com	Lab Kampus	24
Edit Copy Delete	102	Relawan 1	100.65	97%	relawan1@gmail.com	Lab Kampus	24
Edit Copy Delete	103	Relawan 1	97.46	97%	relawan1@gmail.com	Lab Kampus	24
Edit Copy Delete	104	Relawan 1	97.57	97%	relawan1@gmail.com	Lab Kampus	24
Edit Copy Delete	105	Relawan 2	91.55	98%	relawan2@gmail.com	Lab Kampus	22
Edit Copy Delete	106	Relawan 2	88.02	98%	relawan2@gmail.com	Lab Kampus	22

Figure 6. The database of saved data

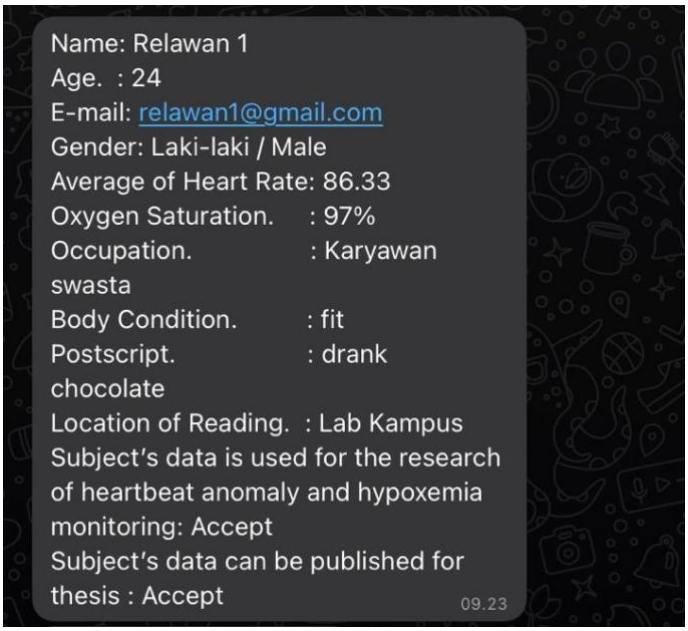

Figure 7. The content example of sent data to Telegram

Results and Discussion

This research asked ten students as the volunteer. The volunteers were read the heartbeat and Oxygen levels by placing the fingertip in front of the sensor or design oximeter and an oximeter made by Mixio. The reading process had been repeated ten times for each volunteer. When the reading process was happened, the volunteers were sitting positioned and their used hand for the testing was on the desk. The range of reading data was one minute or until the sensor condition met. The results of this research are shown in Table 3. Table 3 shows the device reading with various condition from the volunteer. The formulations for calculating error are in (1) and (2) which K is the reading of oximeter made by Mixio and OIoT is the reading of design oximeter. Based on Table 2, there are some errors higher than 1% and it is not specified for certain conditions. The final errors average for reading the beat per minute (BPM) and Oxygen saturation (SpO2) are 0.85% and 0.89% respectively.

$$\%error = \frac{K - OIoT}{K} \times 100\% \qquad (1)$$

$$\%\ average\ error = \frac{\sum \%error}{The\ number\ of\ errorr} \times 100\% \qquad (2)$$

In addition to device reading, the transfer data system was tested too. The result can be shown in Table 4. Each volunteer data was sent to the database and Telegram ten times. All data was sent to the database successfully. Meanwhile, there are three data that cannot be sent to Telegram.

Table 3. The error reading of designed oximeter

Volunteer	Average Error		Average		Condition
	BPM (%)	SpO2 (%)	BPM	SpO2 (%)	
1	1.17	0.41	95.9	97.7	Normal
2	0.22	0.51	91.5	98.2	Tired
3	0.50	1.01	77.9	96.9	Menstruation
4	1.23	1.02	83.3	97.2	Menstruation
5	0.70	2.14	85.9	95.9	Flu
6	1.49	0.93	80.3	98.3	Sleepy
7	0.76	1.21	81.7	97.5	Normal
8	1.53	0.81	88.0	97.5	After Running
9	0.44	0.41	91.4	96.9	Sleepy
10	0.46	0.41	87.2	98.0	Normal

Table 4. The number of data successfully to be sent

Volunteer	The Number of Data	
	Database	Telegram
1	10	10
2	10	10
3	10	10
4	10	10
5	10	10
6	10	10
7	10	10
8	10	10
9	10	10
10	10	7

Conclusion

From the process of the research about design oximeter based on MySQL and Telegram, there are some results that can be concluded. One of them is the average reading error from all volunteers for BPM and SpO2 which are 0.85% and 0.89%. For the data transfer, there are only three data that failed to be sent to Telegram because of the disturbance of internet connection. The last result from this research is no anomaly heartbeat and hypoxemia to be found in ten volunteers. All the results show that the designed oximeter is good enough to be used. Hopefully, this research can be one of the foundations to improvise or develop better oximeter system.

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