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Head Rate Monitoring Using Pulse Sensor as Early Warning for Heart Condition

Nurul Fahmi[1], Nurul Sofiani[2]

[1,2]*Informatic Engineering, Politeknik Negeri Bengkalis, IndonesiaCorresponding Author: Nurul Fahmi*

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ABSTRACT:
The heartbeat is one of the body signals that can be monitored to determine a person's health condition. With the advancement of modern technology, heart rate monitoring devices are now available for everyone, but the diagnosis of heart signals still needs to be done by doctors or medical professionals. In the modern era, many people do not have time to get their health checked, so an alternative system that can connect personal heart rate monitoring devices to doctors is highly needed. A heart rate monitor device can be created using a pulse sensor attached to an Arduino Uno. This device generates heart rate conditions and also has internet access to store the data. The pulse sensor, which functions to detect human heartbeats, can be placed in three measurement locations: the finger, ear, and forehead, which are then processed by the Arduino Uno as the central system. The measurement results, known as Beats Per Minute (BPM), will be displayed on an Android interface connected to a database. From the test results, the average measurement of the heart rate using the device was 77 BPM (Beats Per Minute), while the manual measurement was 76 BPM (Beats Per Minute), indicating that the accuracy of this device reached 98.32%. It takes 60 seconds to display the average value of Beats Per Minute (BPM).

KEYWORDS: Arduino Uno, pulse sensor, Heat Rate

I. INTRODUCTION

With the advancement of technology in everyday life, it has been greatly felt by everyone. Developments in the field of electronics occur constantly, ranging from very simple things. In fact, electronic technology advancements can now be applied in the medical field, especially in measurements. Among other things, it can be used as a health monitoring tool, an aid in healing, and so on. In the initial stage of medical examination, a medical check-up is usually conducted before a person's illness is diagnosed. The results of the medical check-up will determine whether a person is in a healthy condition or not.[1]

In general, the first medical check-up conducted in a hospital is usually the heart rate measurement. This is done because the heart is the main organ in the human body, and its functioning affects other important organs. Based on this condition, the health of the human heart should be given proper attention. One proactive step that can be taken is to regularly check the heart rate. However, performing this check can be considered both easy and difficult. If we opt for manual methods, we need to carefully calculate and have a basic understanding of the principles of heart rate measurement.[2]

This GPS and Android-based monitoring system is designed with the aim of protecting patients, especially those at risk, such as the elderly, from sudden death at the location of a recurring heart attack. Real-time identification of abnormal heart activity, temperature, and respiration, as well as the detection of the location of recurring heart attacks, are carried out using GPS technology without limitations of location, distance, and time. This device utilizes a microcontroller as a data processor from the sensors, which will make logical decisions for the buzzer to sound an alarm for the patient and the user application if the logical conditions meet the critical condition of the patient. The user application is built using Java programming language and utilizes a web service for data transmission. The results of this research are expected to provide a response to the early rescue treatment for patients who suddenly experience recurring heart attacks by sending an alarm as a danger signal, thus reducing the risk of paralysis, coma, and even death[3]

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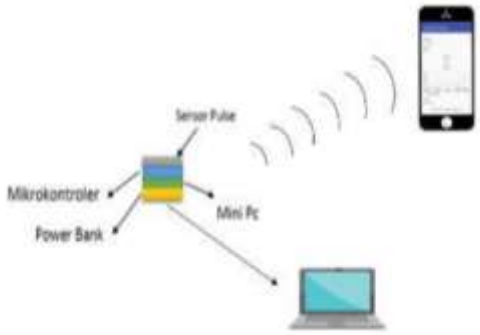
II. METHODOLOGY

1. Prototype Design

The general system design showcases all the necessary equipment needed to create the system. This design is useful in understanding the overall performance of the system. However, it does not provide detailed explanations of each function of the tools used in the design. The general system design, which outlines the workflow of the system, can be seen in Figure 1.



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2. Design General System

The general system diagram design will display all the necessary equipment for creating a prototype heart rate monitoring system, as well as the design flow of these tools. This design is useful for providing a high-level understanding of the workflow of the system. The system's workflow can be visualized through the flowchart shown in Figure 2.

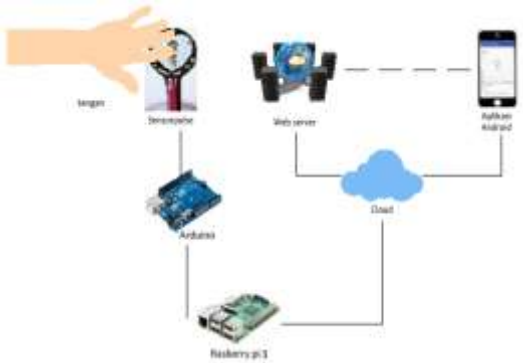

Figure 2. Design General System

III. RESULT

This research has produced a prototype for measuring heart rate to determine the condition of the heart. This device provides information about the patient's heart rate, which is read using a pulse sensor. The heart rate value read by the pulse sensor is sent to the Android application, which is connected to a server on a mini-PC that stores the heart rate values in a database. The displayed information includes the patient's name, entered on the initial screen of the application, the heart rate value, and the time of measurement. If the average heart rate falls within the normal range (60bpm-90bpm), the application will display a message indicating an ideal body condition. However, if the heart rate is outside that range, a warning message will appear, advising the patient to consult a doctor.

The heart rate monitoring application is developed based on the application design to ensure that the created application meets the research objectives. The application is built on the Android platform, and the recommended operating system version for monitoring is Android v6.0.1 (Marshmallow). It is developed using Android Studio, which is a popular integrated development environment for Android app development.

The human heart rate monitoring application is named "Heart Rate App". The application is designed with four interface screens. **Login Screen:** The initial screen that allows users to log in to the application. It provides access to the monitoring screen and patient history. **Monitoring Screen:** The main screen that displays the real-time movement of heart rate values during the measurement process. It shows the continuous changes in heart rate as the monitoring is being conducted. **Heart Rate Result Screen:** This screen displays the latest recorded heart rate value obtained during the monitoring process. It shows the user's most recent heart rate reading.

Patient History Screen: This screen allows users to access and view the history of previously recorded heart rate measurements. It provides users with the ability to review their past heart rate data.

The designed application serves as a tool to facilitate the reading of heart rate values and viewing the history of previously measured heart rates. To use the application, the smartphone needs to be connected to the internet so that it can fetch the heart rate data from the database on the web server. The application interface can be seen in Figures 3 and 4

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Figure 3. The Login Interface and Heart Rate Monitoring Interface

Figure 4. The Heart Rate Value Interface and Patient History Interface

Figure 5. Heart rate measurement using a pulse sensor

During the testing, it can be observed that the prototype equipment has performed well according to the designed specifications. The heart rate sensor successfully reads the heart rate value by placing the finger on the pulse sensor. The testing process is depicted in Figure 5 above.

The examination of the patients' heart rate conditions was conducted randomly, involving 5 individuals as samples. The heart rate examination was performed using manual method and pulse sensor. Each examination lasted for 1 minute. The first test result was obtained by using the pulse sensor to check the patients' heart rate conditions.

The values obtained from the calculation are considered as the heart rate values of the patients when examined using the pulse sensor. The heart rate values of the patients examined using the pulse sensor can be seen in Table 1

Table 1. The heart rate values of the patients when examined using the pulse sensor.

No.	Nama	Denyut Jantung Dengan Sensor	Waktu Pengukuran
1	Nurul	81	1 menit
2	Lutfi	106	1 menit
3	Ilham	161	1 menit
4	Nurul fahmi	78	1 menit
5	Wulan	89	1 menit

From the examination results, two sets of tests were conducted. In the first test, the heart rate was examined using the pulse sensor alone. In the second test, the heart rate was examined manually for the same duration. Then, a comparison of accuracy was made based on the results of the two examinations. This comparison aimed to assess the level of accuracy of the pulse sensor in measuring the heart rate. To determine the accuracy percentage, the heart rate values obtained from the pulse sensor were divided by the values obtained from the manual examination, and then multiplied by 100 to obtain the accuracy percentage according to Equation 1.

$$Accuration\ (\%) = \frac{sensorpulse}{manual}\ x\ 100 \qquad (1)$$

The formula to determine the percentage error from the pulse sensor examination is to first subtract the heart rate value obtained from the pulse sensor from the heart rate value obtained from the manual examination, resulting in an absolute value. An absolute value is a value that does not have a negative (-) sign, even if the actual result of the subtraction is negative. Then, the result of the subtraction is divided by the heart rate value and multiplied by 100 to obtain the error percentage. The formula can be seen clearly in Equation 2.

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The error rate can be calculated by subtracting the heart rate value obtained from the pulse sensor examination from the heart rate value obtained from the manual examination. The absolute difference between these two values represents the error. The error rate can be expressed as a percentage by dividing the absolute difference by the heart rate value from the manual examination and multiplying by 100. This indicates the percentage deviation or error between the two measurements.

$$Error\ Rate\ (\%) = \frac{sensorpulse - manual}{manual}\ x\ 100\ (2)$$

From the calculations, the error rate of the sensor pulse in measuring the patient's heart rate was determined. The error rate of the sensor pulse can be seen in Table 2.

Table 2. Comparison of Accuracy: Heart Rate Values from Sensor Pulse vs. Manual

No.	Nama Anak	Denyut jantung dengan sensor	Alat Ukur manual	Tingkat Akurasi (%)	Tingkat *Error* (%)
1	Nurul	81	82	98	1
2	Lutfi	106	100	106	6
3	Ilham	161	101	159	59
4	Santika	78	76	102	2
5	Wulan	89	80	111	11

In Table 2, it can be seen that the sensor pulse has a low level of error, as observed from the range of error margin which ranges from 0.69% to 1.84%. This can also be seen from the difference in heart rate values between manual and sensor pulse, which ranges around 78. With the low level of error of the sensor pulse, it can be concluded that the sensor pulse has a relatively high level of accuracy. The high level of accuracy can be further proven by calculating the percentage of accuracy using the formula.

Figure 6. The Heart Rate Examination Graph of Ilham

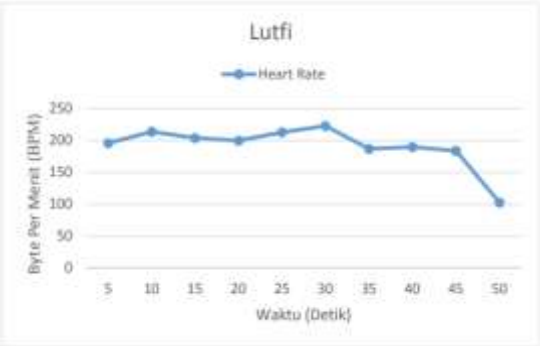

Figure 7. The Heart Rate Examination Graph of Lutfi

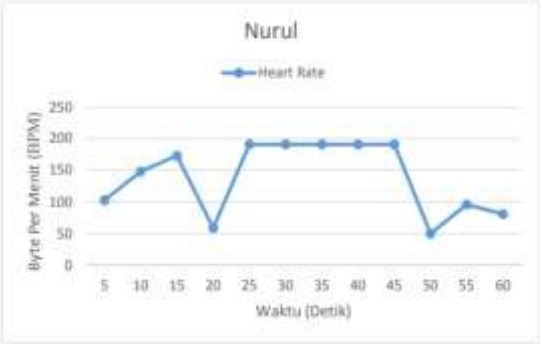

Figure 8. The Heart Rate Examination Graph of Nurul

Figure 9. The Heart Rate Examination Graph of Wulan

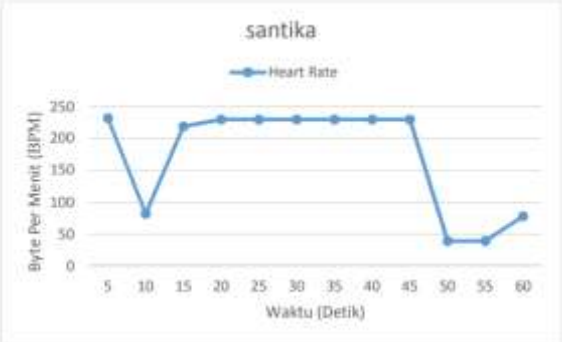

Figure 10. The Heart Rate Examination Graph of Santika

In Figure 6 to 10, it can be seen that the heart rate examined using the manual method and the pulse sensor have a very small difference. Therefore, the pulse sensor can be used as a tool to examine the heart rate due to the narrow range of comparison between the values of the heart rate.

IV. CONCLUSION

Based on the discussion above, it can be concluded that the heart rate monitoring application serves as a control to monitor the patient's heart rate. It provides information about the heart rate using the pulse sensor to both the patient and the doctor who have the dedicated heart rate reading application.

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