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Heart Rate Monitoring, Blood Oxygen Levels and Location Determination for Covid 19 Patients Using Internet of Things Technology

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ABSTRACT

The COVID-19 virus is very dangerous. In addition to attacking the lungs, this virus can also attack the heart directly. The relationship between heart health and COVID-19 occurs because blood vessel clots in COVID-19 patients increase the risk of blood vessel disorders and make the heart work harder. Therefore, researchers designed a heart rate monitoring device. This tool serves to maintain heart health and oxygen levels in the patient's blood and can also monitor people under COVID surveillance. The formulation of the problem from this research is how to design an IoT system to monitor COVID-19 patients through heart rate and location and how it performs. The purpose of this study is to analyze the performance of the device and design a tool to measure heart rate and blood oxygen levels through the IoT system and GPS location so that doctors can access heart rate data from any location. This research method uses a Gy-MAX30100 sensor, Wemos, and a GPS module. Of the 2 data samples that have been tested, the highest heart rate value is 78 bpm, the lowest is 76 bpm, and the highest oxygen level is 95 mmHg and the lowest is 93 mmHg. So in conclusion, this tool can make it easier for doctors to get important information about the condition of patients or people under observation that can be accessed by doctors anywhere and anytime via the internet.

INTRODUCTION

The heart is a very important part of the human body. In the human body, the heart is the last defense of life after the brain. The pulse of the heart works on its own and cannot be controlled by humans. Heart rate is represented as a beat per minute (BPM). Every normal human heart rate ranges from 60 to 100 beats per minute; if the number is more or less, then it is categorized as abnormal. Polluted environmental conditions and air pollution contaminated with viruses can endanger the heart. The virus can be transmitted to other living things quickly and freely through the air. At the end of 2019, the COVID-19 virus was found in Wuhan. The virus is very dangerous and attacks breathing, resulting in fatalities, and the Corona virus has spread widely throughout the world. This research is very important based on statistical data on the spread of COVID-19, which is increasing in several cases. The heart is one of the most important organs in the human body. It acts as a pump for the body's circulation of oxygen and blood, so all functions of the body are not intact. A heartbeat can be defined as the pumping of two halves of the heart that occurs for almost a second. In addition, COVID-19 is considered a respiratory disease that attacks the lungs, but the danger to the heart is also something to be aware of. Cardiologist Vito Anggarino Damay said that around 49% of COVID-19 patients who have severe symptoms and are admitted to the ICU (intensive care unit) suffer from heart inflammation. COVID-19 can attack the heart directly. Doctor Vito explained that COVID-19 patients can experience myocarditis, or inflammation of the heart muscle, even though they have no previous history of heart disease. The link between heart health and COVID-19 also occurs due to the tendency for blood vessel clotting in COVID-19 patients. Blood vessel clotting increases the risk of blood vessel disorders and makes the heart work harder. According to Dr. Vito, this condition is one of the factors that make COVID-19 patients experience worsening and even die. In this day and age, health-related problems are very common. Heart disease is one of the most prone diseases to cause death among men and women; it claims about 1 million deaths every year. Heart rate is an important parameter in the functioning of the heart. Therefore, heart rate monitoring is very important in the study of cardiac performance and maintaining cardiovascular health. In this proposal, an IoT-based system has been implemented that can monitor the heart rate from the output given by the hardware system, which consists of a NodeMCU, breadboard, jumper cables, heart rate sensor, GPS module, and a 3.5V–5V dc adapter. In this case, the researchers designed an IoT system for monitoring COVID-19 patients through heart rate and location so that doctors can access patient heart rate data from any location. This proposal monitors heart monitoring in COVID-19 patients and function detection systems using IoT. Today's medicine is heart-related and requires continuous, long-term monitoring. IoT is very useful in this aspect because it is a monitoring system with a more efficient scheme. Important information about the patient's condition can be accessed by doctors at any place and

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at any time via the internet. GPS technology is used in the software system to determine the immediate location of the device. In addition to the patient, it can be used by doctors to analyze the patient's heart condition.

LITERATURE REVIEW

The heart is one of the most important organs in the human body. It functions as a pump to circulate oxygen and blood throughout the body, thus keeping the body's functions intact. This research proposes a heart rate monitoring system and detects abnormalities using an Internet of Things (IoT)-based system. In the current era, the treatment process for most heart-related diseases requires continuous (real-time) and long-term condition monitoring. IoT systems are very useful in this aspect because they can replace conventional monitoring systems with more efficient schemes by providing important information about the patient's condition that can be accessed by doctors in remote places at any time via the internet. In addition, the nurse or duty doctor in the hospital can monitor the patient's heart rate through a serial monitor in real time. This system also includes notification of the patient's heart rate condition falling below or exceeding a certain value. The doctor receives a warning message through the application on the smartphone. Patient location determination technology using GPS is used in the software system to monitor the location of the device directly. The prototype can also store heart rate data and other details about the patient. The suggested prototype consists of hardware and software components. The hardware consists of a NodeMCU, a pulse sensor, and an LCD display. The software consists of two IoT platforms: Adafruit (along with GPS technology) and Blynk, along with a mobile app. The system is based on a portable heart rate monitoring system designed in a cost-effective manner. The prototype is also easy to use and access. And it can also be used by people of different age groups. Real-time data can be viewed as well as stored for future studies with respect to the patient's heart condition. A system based on ECG sensors and pulse sensors was adapted to design a wristband for early detection of heart attacks and immediate availability of medical facilities (Prasath et al., 2023). The proposed layout consists of a smart bracelet using IoT technology, where the communication device is carried out possibly by using a Bluetooth device. The prototype is based on Lilypad Arduino and Android applications; in addition, a panic button is provided as part of the alert system in case of heart attack detection. In addition, a mobile app named ECG Analytics is used to analyze the data collected from the sensors (Malini Prema Kumari & Victor, 2019). Real-time monitoring of heart rate is possible through the Thing Speak platform.

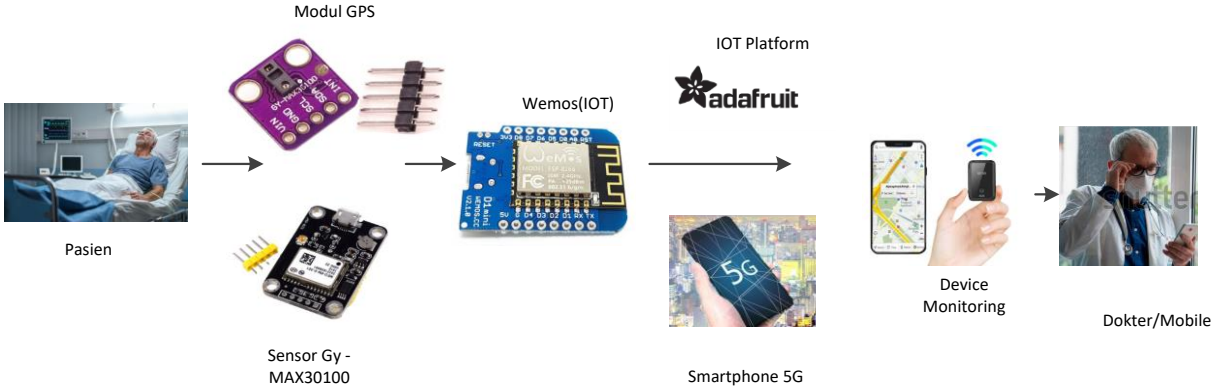

Figure 1. Block Diagram Representation of the Tool Prototype

The heart rate sensor, Wi-Fi module, and Arduino are used as the main components in modeling the heart rate monitoring system (Chirakanphaisarn et al., 2018). Combining IoT with this through a heart rate app is used to get alert messages, considering a heart attack occurred. Heart rate measurement and analysis for subjects belonging to the age group of 20–80 years were done(Chirakanphaisarn et al., 2018). Data is obtained from sensors by detecting light intensity. The output from the sensor is processed into a hub and sent to the software display unit. This data is further stored on an SD card to keep a record of a person's heart rate characteristics.

The pulse sensor is used along with the temperature sensor for heart rate monitoring and heart attack detection (Sihombing et al., 2020). An Arduino board is used based on the algorithm. A GPS module is incorporated to locate the specific location of the patient. An Android application is developed, and communication is possible through a Bluetooth module. The IR sensor is incorporated with the hardware system along with Arduino to generate PPG (photoplethysmography) (Farin et al., 2016). The signal is obtained from the tip. The software used for graphical representation and analysis is processing software.

Sensors collect physiological data from the human body, and the management unit is used to store and display real-time data from the monitoring body (Marimuthu et al., 2013). The management unit can be combined with the IoT system, which is a local host network. The results are presented via monitor, cell phone, or laptop. The hardware system consists of an Arduino UNO, a pulse sensor, an LED, and a Raspberry Pi 3 (Rahman et al., 2021). ThingSpeak, an IoT platform, is used for real-time data monitoring. The IR emitter detector pair is used for heart rate measurement, and the

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output of the sensor is again amplified by the IC741 OPAmp (Sarala, 2022). A low-pass filter is used to remove noise from the signal. The ECG waveform can be visualized on a personal computer screen. The data is uploaded to the cloud database via the WiFi module.

There are many health monitoring systems available today. Wireless communication, wearable devices, and portable remote health monitoring systems are some of them (Malini Prema Kumari & Victor, 2019). Health monitoring systems have been designed to make healthcare facilities easily available and convenient for the patient, and the most important information regarding the patient's health status should be easily accessible to the doctor regardless of the location. IoT plays a key role in this scenario. Frambos Pi is used in various aspects of many monitoring systems today. ECG analysis is essential in diagnosing heart health, irrespective of age group (Murali, 2023). The signals collected from wearable monitoring nodes are sent to the cloud. A WiFi module is usually used to achieve this. The IoT cloud comes with HTTP and MQTT protocols. It plots the data into graphs and also supports real-time monitoring. A prototype was developed for heart rate monitoring as well as interbeat intervals in individuals (Rahman et al., 2021). This was realized through JavaScript, using a Samsung Gear S3 wearable smartwatch with Web library sockets. The communication between the Samsung Gear S3, server, and client was implemented through Java algorithms. Heart rate monitoring is an important factor in the health care of people suffering from cardiovascular diseases, especially in the case of elderly patients (Sarala, 2022). The proposed system consists of an electrical optical sensor, an embedded system, and a Bluetooth-enabled hands-free module. The heartbeat signal is collected at the fingertip. The designed system is enabled by the provision of being able to contact a doctor at a remote location during emergency situations. Abnormal electrocardiogram signals can be monitored using a remote monitoring system, and the data can be transmitted automatically via cell phone messages (Kanimozhi et al., 2018). This is achieved using a GSM model. The components used are a heart rate sensor, MCU, interface circuit, and MODEM. This system uses an AT89C52 MCU. The system requirements for low power consumption and easy operation are met through the internal power source integrated with the AT89C52 MCU. Among the various applications in IoT, smart and connected healthcare is the most important (Malini Prema Kumari & Victor, 2019). IoT facilitates evolution in the practice of medicine, enables personalization of care, and also helps reduce healthcare costs. Real-time monitoring is one of the most important features of IoT.

METHOD

Tools and materials

The tools and materials needed in the IOT system design system for monitoring COVID-19 patients through heart rate, oxygen levels, and location consist of hardware and software, among others:

1. Hardware requirements
   Hardware used in designing IoT system tools for monitoring COVID-19 patients through heart rate and location, among others:

Table 1. Hardware

No	Name	Function
1	Laptop	As a place to run applications in the design of IOT system tools for monitoring covid 19 patients through heart rate and location using the arduino IDE application.
2	Smartphone	As a smart electronic device that doctors / patients use to access covid 19 patient heart rate data through the Blynk application.
3	Jumper	As a link between one component and another.
4	Sensor Gy - MAX30100	As a heart rate detection device for covid 19 patients, it functions to monitor heart rate signals and oxygen levels in the blood.
5	Wemos	IOT device where sensor value readings can be sent via the internet with a Wifi network
6	Gps Module	GPS receiver (Global Positioning System Receiver) serves to detect the patient's location
7	Bateray Cas	Used to charge the battery, if the battery used is exhausted.
8	Bateray	Is a source of current used to run heart rate and location detection devices.

2. Software Requirements
   The software used in the Design of IoT System Tools for Monitoring Covid 19 Patients Through Heart Rate and Location. are:

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Table 2. Software

No	Name	Function
1	Fritzing App	Used for designing IOT system tools for monitoring Covid 19 patients through heart rate and location.
2	Arduino ide 1.8.6 windows	Used to upload the IOT System Tool Design program for Monitoring Covid 19 Patients Through Heart Rate and Location.
3	Microsoft Visio	Microsoft Visio (or often called Visio) is a computer application program that is often used to create diagrams, flowcharts, brainstorms, and network schemes released by Microsoft Corporation.
4	Windows 10	Operating System used to run various applications on Laptop Devices

Research Phases

Tool Preparation Stage

At this stage, prepare the tools and materials needed for this research, such as a PC or laptop, NodeMCU, breadboard, jumper cable, heart rate sensor, GPS, and a 3.50–5 volt DC adapter.

a. Design stage
   At this stage, what must be done is to connect one tool with another so that it becomes a unit.
b. Program Writing Stage
   This stage is done by writing the program syntax into the Arduino IDE.1.8.6 software.
c. Testing Stage
   After the previous stages are done correctly at this stage, all that must be done is to connect the laptop to the tool that has been assembled and upload the program.

Design Chart

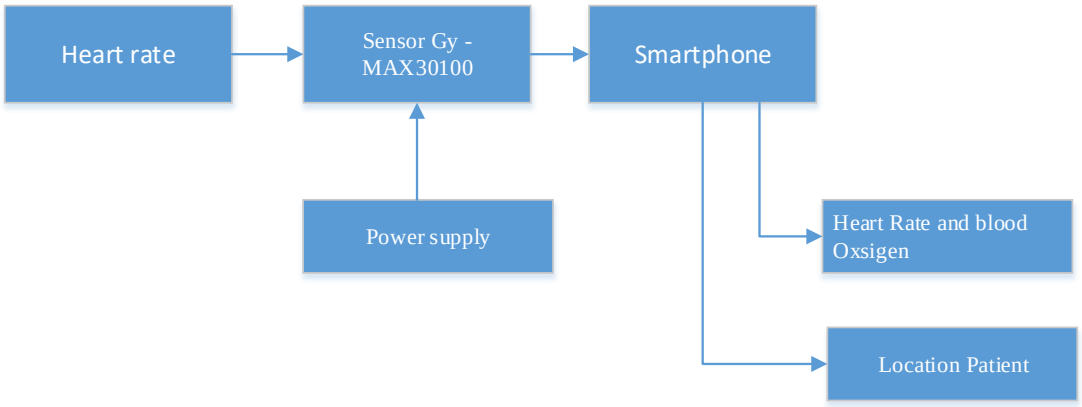

Figure 2. Design Chart

The following is a flowchat design of how the COVID-19 patient monitoring tool works through heart rate and location. As shown in Figure 5, when the system starts running as software and hardware, the program has been imported. It will measure heart rate data and oxygen levels in the blood of patients with Gy-MAX30100 sensors and send the data via the Blynk server so that it can be accessed via an Android-based smartphone.

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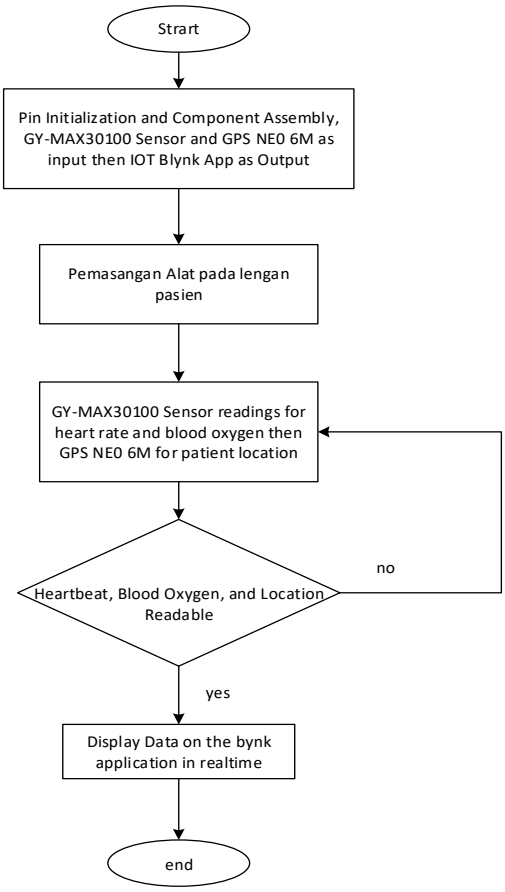

Figure 3. Flowchart of Research and Data Collection

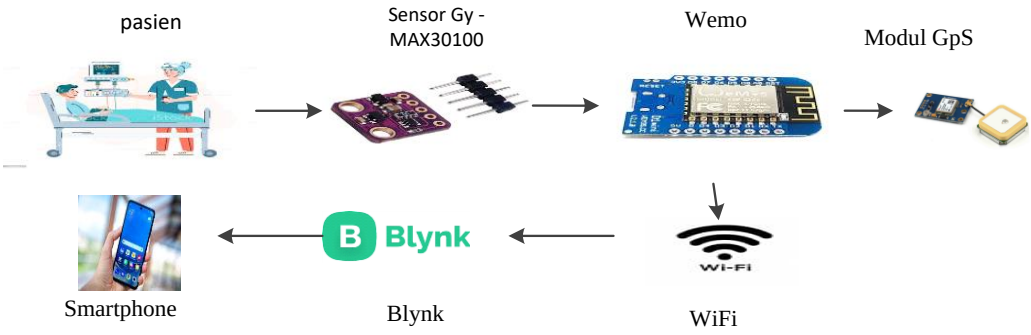

Figure 4 Skematic Design

Figure 4 shows that there are seven parts to the circuit, namely:

a. The patient is the main purpose of monitoring.
b. The Gy MAX30100 sensor is used to measure the patient's heart rate data.
c. Wemos is used to run the microcontroller function and also the internet connection (WiFi). There are several I/O pins so that it can be developed into a monitoring or controlling application in the IOT project.
d. The GPS module is used as a tool that serves to detect the location of the patient; WiFi is a connection tool between Wemos and a smartphone.
e. Blynk is software that is used as a controller of heart rate data and oxygen levels in the blood remotely, wherever the patient is located, with a record connected to the internet.
f. A smartphone is an electronic smart device.

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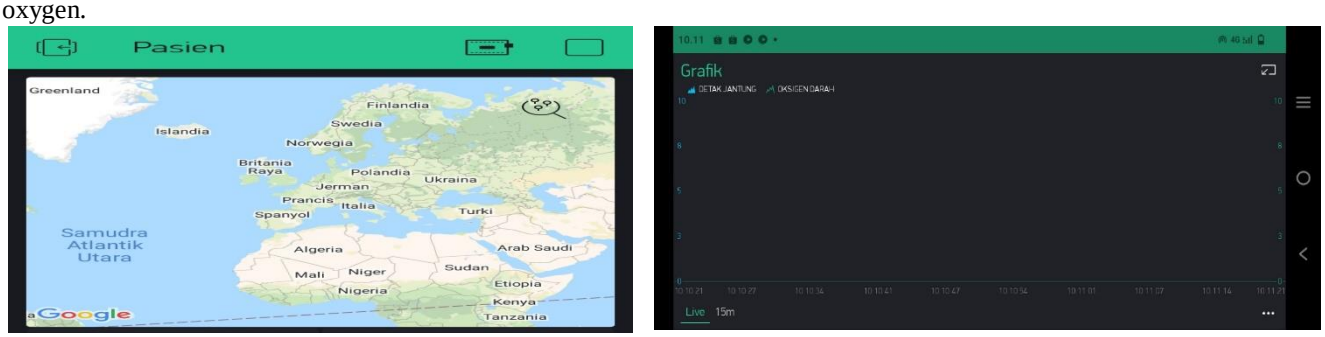
RESULT

The icon display in the Blynk application has been adjusted to the program that has been made on the Arduino idea. Figure 5a is the initial display of GPs after being programmed, and Figure 5b is the initial display of heart rate graphs and oxygen levels. The blue color is marked with heart rate values, and the green color is marked with blood oxygen.



(a) (b)

Figure 5. The icon display in the Blynk application

Tool Procedure

After the system is completed, it needs to be tested. Testing is carried out on 2 people or patients for 2 days for 3 tests a day, namely in the morning, afternoon, and evening for 15 minutes. The normal heart rate of adults and adolescents ranges from 60 to 100 beats per minute (bpm), while the abnormal heart rate is below 60 bpm. Normal blood oxygen (O2) levels are around 90–100 millimeters of mercury (mmHg), while abnormal is below the value of 90 mmHg.

Testing is carried out on the patient by placing the monitoring device on the wrist, and the Gy-MAX30100 sensor is placed on the patient's fingertips so that it can detect heart rate and oxygen levels in the blood. Figure 6: Installation of the device on the patient's wrist:

Figure 6. Installation of the device on the patient's wrist

The working principle of the iot system design tool for monitoring COVID-19 patients through heart rate and location is that if all circuits, namely the Blynk and Wemos applications, are connected to the internet or wifi, then connect them with a USB cable to the power bank so that the device can be connected to the electric current. After completion, the Gy-MAX30100 sensor will detect the heart rate and oxygen levels in the blood, and then the gps will detect the patient's location and send the data detected by the sensor and gps to the Blynk application terminal. Monitoring is done for 15 minutes, and then the data will be sent to the doctor or admin email. The following is a display of the data sent by the Blynk application to the email address.

Figure 7. Display of data sent bynk to email address

Description in figure 7 Normal heart rate in adults and adolescents ranges from 60 to 100 beats per minute (bpm), while abnormal heart rate is below the value of 60 bpm. Normal blood oxygen (O2) levels are around 90–100 millimeters of mercury (mmHg), while abnormal is below the value of 90 mmHg. So it can be concluded that the heart rate values and oxygen levels in the first and second patients are normal. While the coordinates of the patient's

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whereabouts can be seen in the monitoring application, namely the Blynk application, The following is a display of the patient's coordinates on the Blynk application:

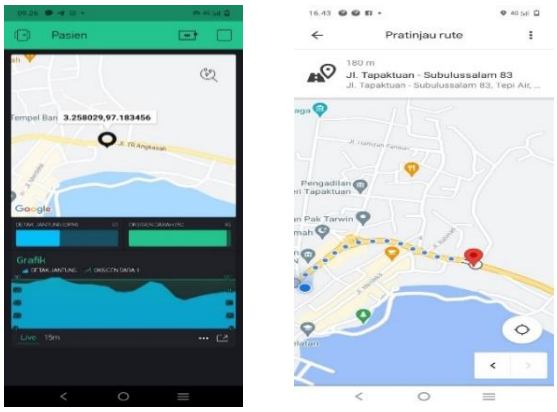


Figure 8. patient location display on google maps

DISCUSSION

1. IoT system tools for monitoring COVID-19 patients through heart rate and kocation can be used by COVID-19 patients for hypoxia and other heart diseases.
2. Suggestions for further research, including adding sensor reading accuracy and having private hosting to make it more private.

CONCLUSION

After designing and building an IoT system to monitor COVID-19 patients through heart rate and location and then testing the device, namely testing heart rate, oxygen levels in the blood, and the patient's GPS or coordinate address, Then conclusions can be drawn:

1. If the Gy MAX30100 sensor is placed on the patient's fingertip, the sensor will detect heart rate data and blood oxygen levels in the patient. After that, the GPS will detect the patient's location and send the data detected by the sensor and GPS to the terminal of the Blynk application. Next, open the data that has been sent to the Bynk application, monitoring trials conducted by researchers for 15 minutes, then export the data, and the heart rate data will be sent via email.
2. Using GPS in order to detect the location of the patient's whereabouts, which can be accessed at any location through the Blynk application.

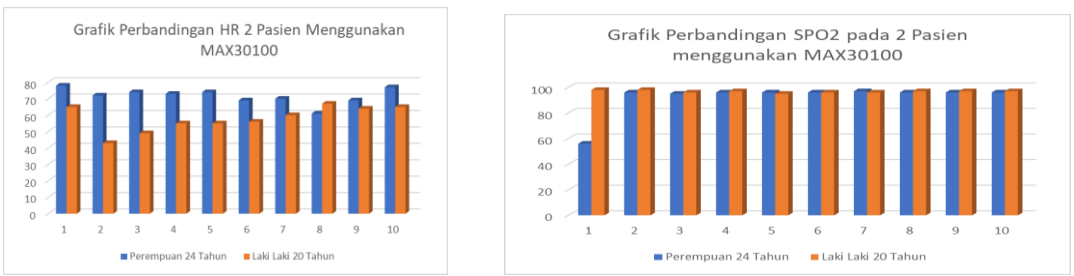
HR Calibration

This calibration compares the HR data read by the MAX30100 sensor with the manual heart rate calculation. Manual heart rate counting is done by counting the number of heartbeats on the subject's left wrist with a calculation time of 10 seconds. To calculate the value of manual heart rate, use the formula:

With Value:

Calculation Time = Time used when calculating heart rate
Number of heartbeats = Number of heartbeats obtained within the calculation time.

The purpose of calibration is to determine the difference between the average of 10 values obtained by the sensor and the average manual measurement in 10 seconds. The difference in value obtained is then used to calculate the accuracy value in percentage form.



(a) (b)

Figure 9. patient location display on google maps

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In Figure 9a, there are 10 data points obtained from the MAX30100 sensor, which is then calculated as the average value and compared with the manual calculation. The average data in Figure 9a is used because the value obtained by the sensor is random when detecting a pulse, in contrast to the manual calculation, which is constant for 60 seconds. Based on figure 9a, the lowest accuracy value is 95.27%, and the highest is 99.25%. The average HR accuracy value is 98.23%. This happens because the MAX30100 sensor reads the pulse on the subject. When the sensor takes readings and the subject makes movements, especially with the finger used to place the sensor, the sensor value will rise and fall.

The measurements in Figure 9b obtained an average accuracy value of 98.99%. Changes in SpO2 values on each device are influenced by the movement of the subject. So that when the subject makes a movement (on the measured finger), then the value of the two sensors will change. However, changes in commercial tools tend to be slower, so the graph displayed looks neat.

This monitoring tool is designed to measure heart rate and blood oxygen levels for COVID-19 patients or even for people with heart disease and hypoxia (lack of oxygen levels). The Gy-Max 30100 sensor will detect heart rate and oxygen levels, and each reading of heart rate and oxygen levels will be displayed on the Blynk application, making it easier for patients or doctors to know the condition and location of the patient's whereabouts. After testing on 2 people/patients each 2 days for 3 times in a day that is morning, afternoon, and night time for 15 minutes, from the sample data that has been tested, the highest value of heart rate is 78 bpm, the lowest is 76 bpm, and the highest oxygen level is 95 mmHg and the lowest is 93 mmHg.

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