Implementation of Non-Invasive Detection of Cholesterol Levels, Hypertension Using Android-Based BPW34 and MPX5050GP Sensors

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Abstract

High cholesterol levels and blood pressure are key indicators of body health that can lead to heart attacks and strokes. Cholesterol deposits in the blood vessels can cause narrowing, resulting in hypertension and disorders of the cardiovascular system. Given the cardiovascular system's role in sending blood to various parts of the body, it is crucial to detect cholesterol levels and hypertension early to prevent heart attacks and strokes.
This study aims to measure cholesterol and hypertension levels using the BPW34 and MPX5050GP sensors, with the addition of the GY-MAX30100 sensor to detect heart rate and oxygen saturation. The three sensors were combined in an experimental analysis test for a prototype medical tool that can measure cholesterol and hypertension levels in real-time and non-invasively (without injuring skin tissue).
An application system was developed in the form of a dashboard displaying the test results from each sensor, which then sends the medical test data to the user's smartphone. This allows users to estimate cholesterol and hypertension levels for initial medical examination.
The results of the research show that the prototype, when compared to standard medical measuring instruments, demonstrates an accuracy of 0.675% on the BPW34 sensor, 3.9% on the MPX5050GP sensor, and 1.475% on the GY-MAX30100 sensor for heart rate, with an accuracy of 1.305% for oxygen saturation.
This system supports personal health management, allowing individuals to monitor their health independently and in real time, enhancing early detection of potential health issues.

Keywords: *cholesterol levels, hypertension, heart rate, oxygen saturation, prototype, measurement, android application.*

1. Introduction

Cardiovascular disease is a disease that is widely faced by modern society today. The disease arises due to implementing unhealthy patterns/lifestyles and has an impact on body health such as metabolic syndrome. This is a group of conditions that increase the risk of heart disease, stroke and diabetes. Metabolic syndrome includes high blood pressure, high blood sugar, excess body fat and abnormal cholesterol levels. The higher the cholesterol levels in the blood, the higher the risk of death from coronary artery calcification.

According to the public relations of Dr. Sardjito Yogyakarta Hospital, a good total cholesterol level in the blood is less than 200 mg/dl, moderate risk between 200 – 240 mg/dl, and high-risk category if the level reaches 240 mg/dl or more (Legal and Public Relations Team of Dr. Sardjito General Hospital Yogyakarta, 2019). Cholesterol has a composition of many substances, including LDL cholesterol (low density lipoprotein), HDL cholesterol (high density lipoprotein), and triglycerides (Centers for disesase control and prevention, 2024). 2 LDL cholesterol functions as a cholesterol transporter to all body cells including blood vessel walls. 3 HDL cholesterol functions to carry cholesterol esters back to the liver from other tissues and lipoproteins. 4 Triglycerides are body fats that in the blood are arranged into lipoprotein forms (Kenneth R & Feingold, 2024).

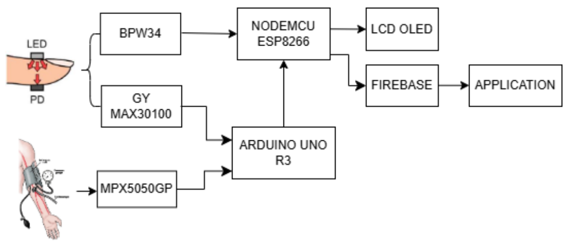
Generally, cholesterol level detection measurement uses an invasive method, namely using a portable easy touch blood test strip. Blood taken from the body is placed on the strip and then the device will measure cholesterol levels in a few minutes and the measurement results will be visible on the measuring device screen. Although more accurate, invasive blood cholesterol level measurement can have several disadvantages, including the cost of the examination which is quite expensive, the results of laboratory analysis take quite a long time, can cause pain in the part of the body that is pricked by the needle, and can cause fear (phobia) for some people.

With the development of science and technology, it is very possible to develop and realize non-invasive blood cholesterol level measurements, namely by utilizing sensor technology with near infrared (NIR)/laser absorption of liquid media. The concentration of fluid (blood) will affect the electrical changes of the medium which can be used to distinguish the content of certain elements or chemicals in the blood. Non-invasive actions can be interpreted as actions taken from outside the body. In addition, because of its non-surgical nature, non-invasive procedures certainly have advantages, namely being safer, more comfortable and without risk (Bick et al., 2020).

The following study aims to detect and measure total cholesterol levels in the blood which is equipped with hypertension detection using the MPX5050GP sensor type and is equipped with the GY-MAX30100 sensor as a detector of oxygen saturation in the blood and heart rate.

2. Methods

The type of research to be conducted is a type of development research where this research develops the shortcomings of previous research. This research is used to produce a prototype in the foGYrm of a cholesterol and blood pressure measurement system using the BPW34 and MPX5050GP sensors, and is equipped with a GY-MAX30100 sensor which functions as a heart rate and oxygen saturation scanner. This tool can be used without having to take a blood sample but only by using a sensor that is reflected through the blood flow, this development is carried out through several stages and testing.



Picture 1. Block Diagram System

Picture 1. The diagram above is a health monitoring system that involves several sensors, a microcontroller, and communication with Firebase and a mobile application. This system consists of sensors BPW34, GY MAX30100, and MPX5050GP which function to measure health parameters such as blood pressure, heart rate, and oxygen levels in the blood. The data from these sensors is collected and processed by the Arduino UNO R3, which functions as a slave in this system, while the NodeMCU ESP8266 functions as a master that sends the processed data to Firebase. This function is designed to ease the load on the ESP8266, considering that this controller handles network communication and data storage in Firebase, so that with the Arduino as a slave, the processing load on the ESP8266 becomes lighter. In addition, the data is also displayed locally on the LCD I2C 16x2 to view the monitoring results directly.

Firebase functions as cloud data storage that allows applications to access and display health data in real-time. NodeMCU sends data from the sensor to Firebase using an internet connection, and the mobile application can retrieve the data to display it to the user. This communication process enables remote health monitoring and secure data storage. The mobile application utilizes the Firebase SDK to retrieve data from Firebase and display it in a way that is easy for users to understand.

Regarding sensor calibration, the sensors used in this system, such as BPW34, GY MAX30100, and MPX5050GP, need to be calibrated to ensure measurement accuracy. Calibration is done by comparing the sensor results with standard medical devices, such as a digital tensiometer for BPW34 or a pulse oximeter for GY MAX30100. Usually, calibration is done by comparing the sensor readings with a measuring device that has been proven accurate and adjusting the sensor parameters to match the results. This calibration process is important to improve measurement reliability in healthcare applications.

Compared to smartbands, this system has advantages in terms of measurement accuracy and specialization. Smartbands generally only measure basic parameters such as heart rate and steps, with simpler calibration. Meanwhile, this system combines several sensors to provide more in-depth measurements, including blood pressure and blood oxygen levels, which are usually more accurate and require more thorough calibration. However, smartbands are more practical and easier to use for daily health monitoring, while Arduino-based systems are more suitable for medical or research applications that require more detailed and accurate data.

Picture 2. Diagram Flowchart

Based on Picture 2 diagram flowchart, Arduino and the ESP8266 MCU node. Next, user registration is carried out before testing the device. Then testing by scanning the first index finger for heart rate and oxygen saturation detection by the GY-Max30100 sensor and scanning the second index finger for cholesterol level detection by the BPW34 sensor. The results obtained will be displayed on the LCD display in the form of OLED. If the patient's cholesterol level is normal, the next step is to measure blood pressure by inserting a cuff on the arm. After measuring blood pressure with normal results, the medical results are immediately displayed on the LCD layer stating that the patient is healthy or in other words does not have hypertension with normal cholesterol levels. However, if the results of the patient's cholesterol level detection increase, it is also necessary to measure blood pressure in the same way by inserting a cuff on the arm. After the measurement is carried out and it turns out that the medical results of abnormal blood pressure or the patient has high blood pressure, it can be stated that the patient is in an unhealthy condition. Data from the results of these medical measurements will be sent to the user's smartphone via the Android application to monitor personal health which can directly determine the user's health level from an early age.

3. Results and Discussion

Based on Picture 3, the prototype form of the non-invasive medical measuring instrument has been obtained as follows.

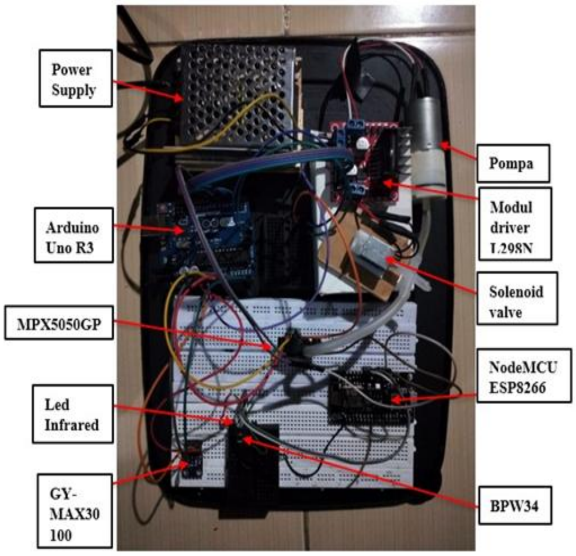
Picture 3. Front view of the tool

Pictures 4, 5, and 6 provide a comprehensive visual of the physical and internal structure of the prototype medical device. Picture 4 shows the left side of the device, highlighting the PSU and Arduino Uni R3 essential for blood pressure measurement. Picture 5 displays the right side, where the NodeMCU ESP8266 and Tensimeter are positioned.

Meanwhile, Picture 6 presents the internal component layout, including the Power Supply, Arduino UNO R3, NodeMCU ESP 8266, pump, driver module, solenoid valve, BPW34, GY-MAX30 100, Led infrared, and MPX5050GP, illustrating how the system is integrated and structured to ensure accurate data processing, stable operation, and user-friendly monitoring.

Picture 4. Left side view of the tool

Picture 5. right side view of the tool



Picture 6. Implementation of Component Layout in the Prototype of Medical Cholesterol and Hypertension Measuring Instruments

System Testing

System testing includes sensor testing and android application testing. Sensor testing consists of GY-MAX30100 sensor testing as heart rate and oxygen saturation detection, BPW34 sensor testing as cholesterol level detection and MPX5050GP sensor testing as blood pressure detection. The results of GY-MAX30100 sensor testing on 5 patients obtained data showing that the average heart rate detection error was 1.4755 and the average oxygen saturation detection error was 1.305%. Table 1 shows the results of GY-MAX30100 sensor testing compared to smartband medical measurements.

The same steps for testing the BPW34 sensor obtained data showing an average error of 0.7625%

when compared to easy touch medical measurements. Table 2 shows the results of testing the BPW34 sensor. Then the last test on the MPX5050GP sensor compared to the omicron brand medical measurement obtained an average error of 3.9%. Table 3 shows the results of the MPX5050 test.

Table 1. GY-MAX30100 sensor testing

No	Patient	Heart rate: GY-MAX30100 Sensor	Heart rate: Smart Band	Eror
1	To-1	78.48 bpm	77.48 bpm	1.29%
2	To-2	74.03 bpm	73.03 bpm	1.37%
3	To-3	79.53 bpm	80.53 bpm	1.24%
4	To-4	85.66 bpm	84.66 bpm	1.18%
5	To-5	73.36 bpm	72.36 bpm	1.38%
6	To-6	73.36 bpm	74.36 bpm	1.34%
7	To-7	86.05 bpm	87.05 bpm	1.15%
8	To-8	80.37 bpm	78.37 bpm	2.55%
9	To-9	71.71 bpm	73.71 bpm	2.71%
10	To-10	78.8 bpm	80.8 bpm	2.48%
11	To-11	71.76 bpm	70.76 bpm	1.41%
12	To-12	71.74 bpm	73.74 bpm	2.71%
13	To-13	76.69 bpm	75.69 bpm	1.32%
14	To-14	61.61 bpm	59.61 bpm	3.36%
15	To-15	62.93 bpm	63.93 bpm	1.56%
16	To-16	71.06 bpm	72.06 bpm	1.39%
17	To-17	67.91 bpm	68.91 bpm	1.45%
18	To-18	77.2 bpm	79.2 bpm	2.53%
19	To-19	68.64 bpm	66.64 bpm	3.0%
20	To-20	65.11 bpm	67.11 bpm	2.98%
21	To-21	85.26 bpm	87.26 bpm	2.29%
22	To-22	73.42 bpm	71.42 bpm	2.8%
23	To-23	75.47 bpm	73.47 bpm	2.72%
24	To-24	65.03 bpm	63.03 bpm	3.17%
25	To-25	71.19 bpm	69.19 bpm	2.89%
26	To-26	75.78 bpm	76.78 bpm	1.3%
27	To-27	66.94 bpm	66.94 bpm	0.0%
28	To-28	77.63 bpm	77.63 bpm	0.0%
29	To-29	70.8 bpm	68.8 bpm	2.91%
30	To-30	72.96 bpm	72.96 bpm	0.0%
31	To-31	70.79 bpm	70.79 bpm	0.0%
32	To-32	87.97 bpm	85.97 bpm	2.33%
33	To-33	74.91 bpm	74.91 bpm	0.0%
34	To-34	67.6 bpm	69.6 bpm	2.87%
35	To-35	80.76 bpm	79.76 bpm	1.25%
36	To-36	66.45 bpm	65.45 bpm	1.53%
37	To-37	76.46 bpm	74.46 bpm	2.69%
38	To-38	61.28 bpm	62.28 bpm	1.61%
39	To-39	65.7 bpm	63.7 bpm	3.14%
40	To-40	76.38 bpm	77.38 bpm	1.29%
Average Eror				**1.8%**

Table 2. BPW34 Sensor Testing

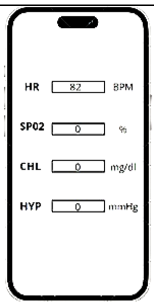
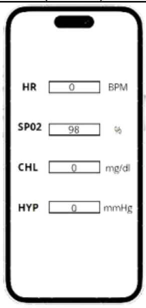
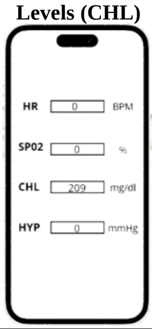
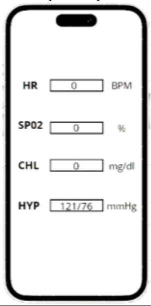
No	Patient	Total Cholesterol Level Value: BPW34 Sensor	Total Cholesterol Level Value: Easy Touch	Error
1	To-1	161 mg/dl	163 mg/dl	1.23%
2	To-2	250 mg/dl	255 mg/dl	1.96%
3	To-3	204 mg/dl	202 mg/dl	0.99%
4	To-4	147 mg/dl	147 mg/dl	0.00%
5	To-5	286 mg/dl	284 mg/dl	0.70%
6	To-6	190 mg/dl	185 mg/dl	2.70%
7	To-7	127 mg/dl	125 mg/dl	1.60%
8	To-8	304 mg/dl	304 mg/dl	0.00%
9	To-9	298 mg/dl	298 mg/dl	0.00%
10	To-10	138 mg/dl	136 mg/dl	1.47%
11	To-11	195 mg/dl	197 mg/dl	1.02%
12	To-12	250 mg/dl	255 mg/dl	1.96%
13	To-13	282 mg/dl	282 mg/dl	0.00%
14	To-14	143 mg/dl	145 mg/dl	1.38%
15	To-15	281 mg/dl	276 mg/dl	1.81%
16	To-16	283 mg/dl	278 mg/dl	1.80%
17	To-17	123 mg/dl	123 mg/dl	0.00%
18	To-18	170 mg/dl	165 mg/dl	3.03%
19	To-19	304 mg/dl	309 mg/dl	1.62%
20	To-20	242 mg/dl	242 mg/dl	0.00%
21	To-21	161 mg/dl	159 mg/dl	1.26%
22	To-22	126 mg/dl	121 mg/dl	4.13%
23	To-23	252 mg/dl	250 mg/dl	0.80%
24	To-24	191 mg/dl	193 mg/dl	1.04%
25	To-25	192 mg/dl	192 mg/dl	0.00%
26	To-26	270 mg/dl	272 mg/dl	0.74%
27	To-27	147 mg/dl	145 mg/dl	1.38%
28	To-28	144 mg/dl	146 mg/dl	1.37%
29	To-29	205 mg/dl	207 mg/dl	0.97%
30	To-30	300 mg/dl	300 mg/dl	0.00%
31	To-31	306 mg/dl	306 mg/dl	0.00%
32	To-32	268 mg/dl	268 mg/dl	0.00%
33	To-33	161 mg/dl	156 mg/dl	3.21%
34	To-34	275 mg/dl	273 mg/dl	0.73%
35	To-35	238 mg/dl	233 mg/dl	2.15%
36	To-36	309 mg/dl	311 mg/dl	0.64%
37	To-37	140 mg/dl	140 mg/dl	0.00%
38	To-38	219 mg/dl	217 mg/dl	0.92%
39	To-39	295 mg/dl	293 mg/dl	0.68%
40	To-40	267 mg/dl	262 mg/dl	1.91%
Average Eror				**1.13%**

Table 3. MPX5050GP sensor testing

No	Patient	Blood Pressure Value: MPX5050GP Sensor	Blood Pressure Value: Omicron	Eror
1	To-1	121/79 mmHg	129/83 mmHg	5%
2	To-2	121/78 mmHg	123/66 mmHg	5.9%
3	To-3	121/76 mmHg	107/66 mmHg	2.8%
4	To-4	121/79 mmHg	116/73 mmHg	2%
5	To-5	160/93 mmHg	161/91 mmHg	≈ 0%
6	To-6	121/79 mmHg	129/83 mmHg	5%
7	To-7	121/78 mmHg	123/66 mmHg	5.9%
8	To-8	121/76 mmHg	107/66 mmHg	2.8%
9	To-9	121/79 mmHg	116/73 mmHg	2%
10	To-10	160/93 mmHg	161/91 mmHg	≈ 0%
11	To-11	121/79 mmHg	129/83 mmHg	5%
12	To-12	121/78 mmHg	123/66 mmHg	5.9%
13	To-13	121/76 mmHg	107/66 mmHg	2.8%
14	To-14	121/79 mmHg	116/73 mmHg	2%
15	To-15	160/93 mmHg	161/91 mmHg	≈ 0%
16	To-16	121/79 mmHg	129/83 mmHg	5%
17	To-17	121/78 mmHg	123/66 mmHg	5.9%
18	To-18	121/76 mmHg	107/66 mmHg	2.8%
19	To-19	121/79 mmHg	116/73 mmHg	2%
20	To-20	160/93 mmHg	161/91 mmHg	≈ 0%
21	To-21	121/79 mmHg	129/83 mmHg	5%
22	To-22	121/78 mmHg	123/66 mmHg	5.9%
23	To-23	121/76 mmHg	107/66 mmHg	2.8%
24	To-24	121/79 mmHg	116/73 mmHg	2%
25	To-25	160/93 mmHg	161/91 mmHg	≈ 0%
26	To-26	121/79 mmHg	129/83 mmHg	5%
27	To-27	121/78 mmHg	123/66 mmHg	5.9%
28	To-28	121/76 mmHg	107/66 mmHg	2.8%
29	To-29	121/79 mmHg	116/73 mmHg	2%
30	To-30	160/93 mmHg	161/91 mmHg	≈ 0%
31	To-31	121/79 mmHg	129/83 mmHg	5%
32	To-32	121/78 mmHg	123/66 mmHg	5.9%
33	To-33	121/76 mmHg	107/66 mmHg	2.8%
34	To-34	121/79 mmHg	116/73 mmHg	2%
35	To-35	160/93 mmHg	161/91 mmHg	≈ 0%
36	To-36	121/79 mmHg	129/83 mmHg	5%
37	To-37	121/78 mmHg	123/66 mmHg	5.9%
38	To-38	121/76 mmHg	107/66 mmHg	2.8%
39	To-39	121/79 mmHg	116/73 mmHg	2%
40	To-40	160/93 mmHg	161/91 mmHg	≈ 0%
Average Error				**3.1%**

Android application testing is done by displaying the results of patient medical measurement data from each sensor to the smartphone. The following is a table of 4 displays of the android smartphone on the 3rd patient sequence.

Table 4. Displays on Android Smartphone

Patient	**Android Heart Rate (HR)**	**Android Oxygen Saturation (SPO2)**
To-3		
	Android Cholesterol Levels (CHL)	**Android Blood pressure (HYP)**
		

4. Conclusion

This research succeeded in developing a prototype system for Android-based non-invasive medical devices to detect cholesterol levels, blood pressure (hypertension), heart rate, and blood oxygen saturation in real-time. This system integrates three types of sensors, namely BPW34 for cholesterol, MPX5050GP for blood pressure, and GY-MAX30100 for heart rate and oxygen saturation. In the testing process, this prototype was compared with standard medical measuring devices and smartband devices as a comparison for heart rate and oxygen saturation parameters. The test results show that this device has a high level of accuracy, with an average error of 0.675% for the BPW34 sensor, 3.9% for the MPX5050GP, and 1.475% for the GY-MAX30100 for heart rate and 1.305% for oxygen saturation. Compared to a smartband, this system provides more precise results because it has a more complex sensor configuration and goes through an in-depth calibration process. This system supports independent health monitoring, allowing users to monitor their body condition regularly and easily through an Android application that connects to Firebase in real-time. For further development, it is recommended to improve the comfort of the device, simplify the physical form of the device, and test on a wider scale of users so that this system can be practically implemented in everyday life.

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