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Implementation System of Health Care Kiosk for Detecting Cholesterol Disease, Uric Acid, Obesity and Hypoxia

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*Abstract***—** The development of technological advances in the health sector in the last decades has grown very rapidly. Currently, most people do not receive routine medical check-ups because of the long lines of patients and the expensive rates they must pay to see a specialist doctor. This causes many people to ignore the importance of routine health checks as recommended by the National Health Agency. The purpose of this research is to make a device that can perform routine checks independently at home, using an Arduino microcontroller for checking cholesterol, uric acid, obesity, and hypoxia. This tool has several sensors, namely Ultrasonic & Load Cell sensors to measure weight and height, which are used to detect obesity through the BMI table. In addition, there is a Pulse and Oxygen in Blood Sensor (SPO2) sensor to detect heart rate and oxygen saturation to detect hypoxia using the fuzzy logic method. Cholesterol and uric acid examination using the Electrode Based biosensor method with a digital detection device (amperometric biosensor). Testing the Tsukamoto fuzzy logic method system obtained a data accuracy value of 100%, following the rules set for classifying hypoxic diseases. The trial phase was carried out as many as 10 trials, where 90% of patients did not experience hypoxia, and 10% had mild hypoxia. The results of testing the BMI table method system for obesity obtained a data accuracy value of 100% according to the calculation of the BMI calculator. In phase 10 trials, 30% of patients were lean, 50% obese, and 20% obese. The system test results use a range of values, each with a data accuracy value of 100% according to the classification of cholesterol and uric acid levels. Ten trials showed that 70% of patients were in normal condition, 20% of patients with low cholesterol, and 10% of patients were in high limits. As for gout, 70% of patients are in normal condition, and 30% of patients are in high uric acid condition.

Keywords— Ultrasonic sensor, Load Cell Sensor, Electrode-Based biosensor; Pulse and Oxygen in Blood Sensor (SPO2), Fuzzy Logic.

I. INTRODUCTION

In today's era, technological advances are growing rapidly in various fields: health. Technology in the health sector is often associated with biomedical technology. E-Health is a technology development research in the biomedical field to manage health resources and health care [1]. The increasing cases of Non-Communicable Diseases (NCD) will significantly increase the burden on the community and the government because the handling takes a lot of time; it is necessary to create this detection tool for blood sugar, cholesterol, and uric acid [2].

Based on the literature review on previous research, the researcher [3] discusses total cholesterol level examination using electrode-based biosensor method with Spectrophotometric Method, which had results that were not much different or almost the same. Using the electrode-based biosensor method allows people to conduct inspections independently, easily, quickly, and cheaply [3]. A study of SPO2 monitoring through android applications on mobile phones discusses the cause of the chronic obstructive pulmonary disease: smoking [4]. They use the max30100 sensor to monitor oxygen saturation, which determines the SPO2 value in smokers as an early warning of the risk of a smoking lifestyle [4]. The results of the SPO2 detection will be sent and displayed on android. The investigation of optimal body weight utilizing Load Cells and Ultrasound was carried out. [5]. The BMI table was used to classify thin, normal, fat, and obese in this study, while the Brocca method was used to determine a person's ideal weight [5]. The research on Arduino-based ideal height and weight measurements in 2018. This study discussed a person's ideal height and weight using the formula for a weight divided by height, which was then classified with a BMI table for checking obesity [6]. The research [7] was conducted on implementing the Tsukamoto method of the fuzzy logic algorithm, in which two inputs are IP and parents' income to determine the weight of the scholarship. In this method, a rule in the form of IF-THEN is used and uses the AND operation, where the minimum value (MIN) will be chosen from the two existing variables. Design of gout telemedicine (GOUT) based on the Internet of Things (IoT). This study detects gout, where uric acid can cause rheumatic and joint pain [8]. Therefore, checking uric acid using blood to determine uric acid levels. Then the data is processed by Arduino and sent to the web server via WIFI ESP8266. This makes it easier for doctors to monitor patients remotely connected to the internet network [8].

Heart disease is the number one cause of death in the world based on data compiled by WHO. Patients with heart disease can experience sudden disturbances that require rapid treatment so that they are not fatal. Therefore, we need technology to detect the patient's heart rate and provide notifications when problems occur in the patient's heart [9]. Coronary heart is one of the causes of death in various

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developed countries and developing countries due to high levels of cholesterol and uric acid in the blood [10]. Still, it can also be caused by obesity and hypoxia. An electrocardiograph, sometimes known as an EKG, is a device that can be used to monitor the biopotential signals produced by the heart. [11].

Electrocardiographs are generally only available in hospitals. Even though such a system has been developed, problems still arise, such as the limited number of electrocardiographs available. Patients are also required to rent this device and consult a doctor regularly.

This high cost and complicated process cause patients to be reluctant to check their hearts [12][13]. So, a monitoring system for the patient's condition is needed with various aspects such as monitoring heart rate, oxygen saturation in blood levels, cholesterol and uric acid in the body, and indicators. Other health services accurately, with this technology, will facilitate the performance of doctors and medical personnel to conduct patient examinations [14][15]. This research is used to implement a system that can detect cholesterol, uric acid, obesity, and hypoxia in a patient. Data Input is a patient who will do a health check-up, then the patient will use an amperometric biosensor, SPO2 sensor, Ultrasonic sensor, and Load Cell. After using the sensor, it will get health data for cholesterol, uric acid, obesity, and hypoxia, and then the data will be processed into digital data so that it is easy for patients to understand. In order to handle data from the SPO2 sensor, Load Cell, and Ultrasonic utilizing the Arduino UNO microcontroller, which then enters the data transmission stage. At this point, data is passed from hardware to software is sent from hardware to software. The health data will be classified using the fuzzy method for hypoxia, obesity using a BMI (body mass index) table, cholesterol, and uric acid using the range of each value. After that, the patient's condition data will be displayed on the health care kiosk screen.

II. Research Methodology

Health Care Kiosk is a biomedical technology tool that can display information on patient health condition data starting from data on the patient's heart rate, oxygen saturation in the blood, cholesterol, and uric acid levels.

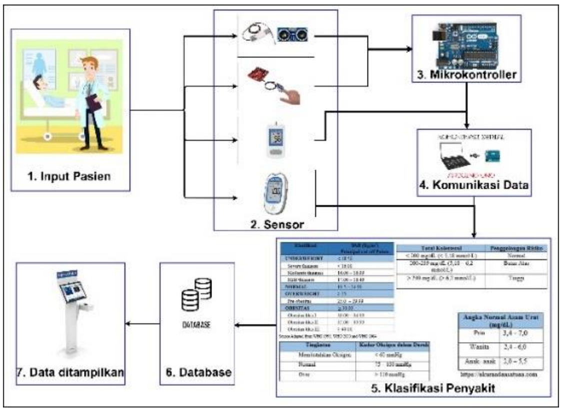

Figure 1. System Design

System design plan and system creation consisting of 6 stages, namely: Patient input data, selection of sensors to be used by patients, data processing by the Arduino UNO microcontroller, disease classification, data results are stored in a MySQL database, then displayed on Health Care Kiosk as described in Figure 1. Based on Figure 1 of the system design, the process carried out can be described as follows:

- Health data input is taken from the patient. The input to this system is a patient who wants to do a health check.
- Then the patient selects the health data to be checked and selects the sensor to be used. The Amperometric biosensor is used to check cholesterol and uric acid. Ultrasonic sensors are used to measure height and Load Cell sensors to measure weight. The results of height and weight can be used to detect obesity. The last sensor is the SPO2 sensor from MySignals to detect hypoxia.
- After getting the patient's health data, the data that has been obtained is processed so that the patient can later read the data displayed on the Health Care Kiosk. This processing uses a microcontroller, namely Arduino UNO.
- Then, the data that has been processed is classified according to the disease classification table, which is useful so that the patient fully understands his health condition. Where in determining the classification of obesity tables using the BMI equation (Body Mass Index), while for classifying hypoxia using the fuzzy method, two sensors entered from the SPO2 sensor, namely oxygen saturation in the blood and the patient's heart rate.
- The results of the checks that have been classified according to the disease classification table will be entered in the MySQL database, then retrieved the patient's medical record data.
- The data is displayed on the Health Care so that patients can see the classification results and the patient's medical record.

A. Input Patient

At this stage, the process of inputting patient data is carried out independently, where the patient performs health checks using several sensors. At this stage, testing for cholesterol and uric acid is not for children but for adults who are prone to cholesterol and gout. At the same time, obesity and hypoxia can be used for all patients.

B. Sensor Selection

Then the patient chooses what health data to check and selects a sensor. In this system, there are five sensors with four different types of health data. In the system, there are five sensors: the Mission Ultra amperometric biosensor, the Accugence amperometric biosensor, the Load Cell, the Ultrasonic, and the Pulse and Oxygen in Blood Sensor, as well as the Ultrasonic (SPO2).

1. Mission Ultra Amperometric Biosensor: The factory has calibrated the sensor. The sensor has been tested at Acon

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Laboratories, Inc. (San Diego, USA) and passed the entry permit to Indonesia after going through the Ministry of Health to guarantee accuracy. In addition, the author also tested the comparison of the sensor results with other brands of Amperometric Biosensors such as Easy Touch GCU for cholesterol checking. The Mission Ultra cholesterol sensor is used in this system, along with how to use the sensor to get the appropriate data, as seen in Figure 2.

Figure 2. How To Use Amperometric Biosensor

2. Accugence Amperometric Biosensor: The Amperometric Biosensensor Accugence sensor has a function to measure uric acid levels. This system uses an invasive method and the Electrode Based Biosensor method (through capillary blood), where patients can perform examinations independently, easily, quickly, and cheaply. Here's how to use the Accugence sensor, as seen in Figure 3.

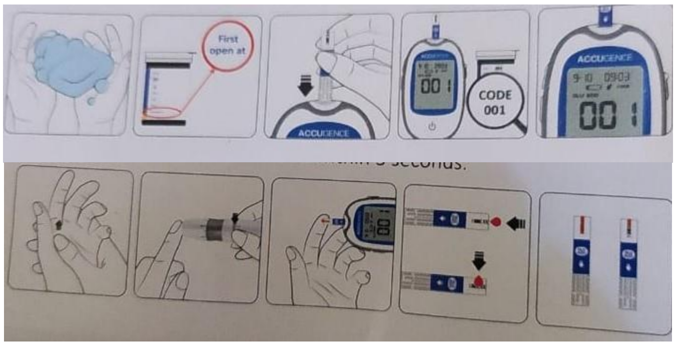

Figure 3. How To Use Accugence

3. Ultrasonic and Load Cell: Then, ultrasonic sensors and load cells are used to detect obesity. Ultrasonic sensors are used to measure height, while Load Cells are used to measure weight. To detect obesity using the BMI table. The illustration in Figure 4 is how to use Ultrasonic sensors and Load Cells. The Load Cell Sensor used has been calibrated using the HX711 library on Arduino to get a calibration factor by testing the Load Cell by giving a definite load / known weight of goods. The author uses body weight by placing both feet on the Load Cell used and then running the calibration program. On the serial monitor, the weight will appear, then change the calibration factor until it is close to the bodyweight following the results of the digital scale. The author gets a calibration factor value of 24580, which is then entered into the program to calculate the weight on the Arduino. While the ultrasonic sensor, calibration is done by limiting the maximum height as high as 2 meters minus the object distance in ultrasonic. In this case, the max height is reduced by the distance of the patient's head from the sensor, thus getting the patient's height value which is then compared with a meter tool to measure the patient's height.

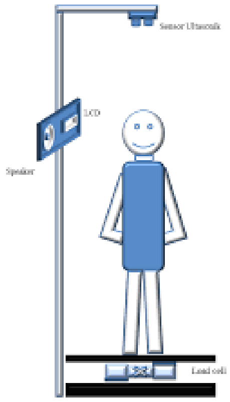

Figure 4. How To Use Load Cell and Ultrasonic

4. SPO2: Finally, an SPO2 sensor from MySignal functions to measure the patient's heart rate per minute and oxygen levels in the blood. This sensor is used on the patient's index finger which is inserted in the SPO2 sensor. The illustration in Figure 5 is how to use the SPO2 sensor.

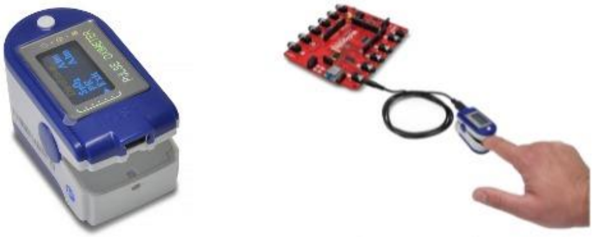

Figure 5. How To Use SPO2 (MySignlas)

C. Data Processing

After the health data is obtained, the next step is to process the data using the Arduino microcontroller. Data processing is needed to convert analog data to digital. In addition, it manages sensor results to be included in the specified disease classification so that patients can easily understand it. As shown in Figure 6, a micro-USB is required to connect the sensor to the microcontroller. The micro-USB is connected from the sensor to the Arduino.

Figure 6. Data Port Amperometric Biosensor

In the Figure 6 above uses a micro usb type B cable to connect the sensor to the Arduino UNO microcontroller, while the amperometric uric acid biosensor (Accugence) uses a USB

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cable to a 2.5 mm jack. Then the data will be displayed on the Arduino IDE serial monitor. As for the Load Cell as seen in Figure 7.

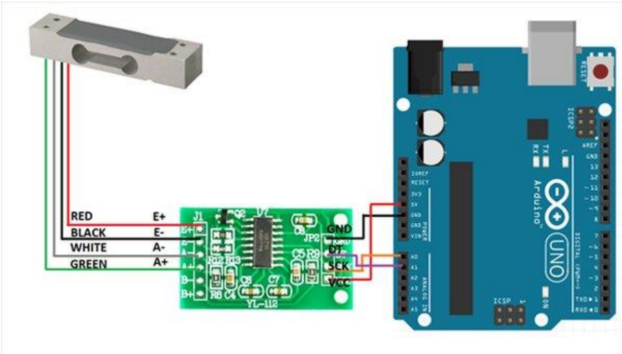

Figure 7. Data Port Load Cell

In Figure 7, connect the Load Cell sensor to the Arduino using Coding 1, where the DT of the Load Cell is connected to pin A1 Arduino UNO, CLK / SCK Load Cell is connected to pin A0.

Coding 1. The Load Cell sensor to the Arduino

```
#define DOUT A1
#define CLK A0
#include "HX711.h"
#include "Wire.h"
float calibration_factor = 24580;
long zero_factor = scale.read_average();
```

Vcc Load Cell is connected to the Arduino Vcc pin, and the last Ground Load Cell is to ground pin Arduino UNO. As for Ultrasonic, as seen in Figure 8.

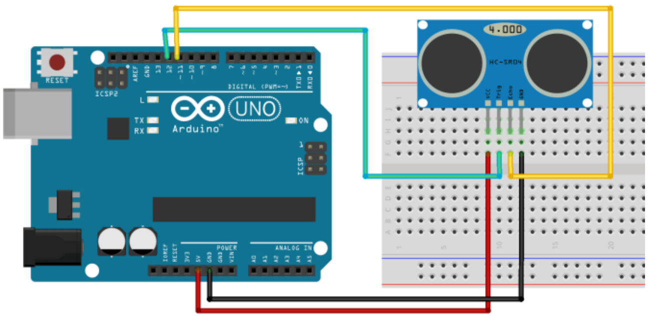

Figure 8. Data Port Ultasonik

Figure 8 connects the Ultrasonic sensor to Arduino UNO, where the trigger pin is connected to pin 11 Arduino using Coding 2. The Echo pin is connected to pin 10 Arduino. This is the coding on Arduino Uno.

Coding 2. The Ultrasonic Sensor to Arduino UNO

```
#define DOUT A1
const int triggerPin = 10;
const int echoPin = 11;
jos = (duration / 2) / 29.1;
tinggiBadan = tinggiMax - jos;
```

The ground pin is connected to the Arduino ground pin, and the last pin is Vcc connected to the Vcc pin Arduino UNO. To connect the last sensor, namely SPO2, is seen in Figure 9.

Figure 9. Data Port SPO2

Figure 9 above connects the SPO2 sensor from the MySignals health platform with the MySignals module based on the Arduino UNO microcontroller. There is an SPO2 micro USB cable from MySignals, a jack connector inserted into the SPO2 port on the module, as shown above. The sensor results can be read on the Arduino IDE using Coding 3.

Coding 3. The SPO2 Sensor

```
#include <MySignals.h>
MySignals.initSensorUART();
MySignals.enableSensorUART(PULSIOXIMETER);
uint8_t statusPulsioximeter =
MySignals.getStatusPulsioximeterGeneral();
if (statusPulsioximeter == 1)
SPO2_value = MySignals.pulsioximeterData.O2;
bpm_value = MySignals.pulsioximeterData.BPM;
```

To bring all sensors together in one location, the microcontroller sends the sensor results to the GUI Health Care Kiosk via serial communication using java to read the port connected to the sensor using Coding 4.

Coding 4. The microcontroller sends the sensor results

```
import gnu.io.SerialPort;
import cl.konek;
import java.sql.Connection;
import gnu.io.CommPortIdentifier;
import gnu.io.PortInUseException;
import gnu.io.UnsupportedCommOperationException;
Serial Serial = new Serial(this);
Connection c = konek.getkoneksi();
Statement s = c.createStatement();
ResultSet r = s.executeQuery(sql);
System.out.println("Result r = ");
System.out.println(r);
```

D. Diseases Classification

At this stage, it is classifying diseases based on health data that has been converted. This classification stage has a function. The system can decide whether the patient is normal or there is a disease suffered by the patient, such as cholesterol, uric acid, obesity, or hypoxia—the normal and abnormal values for cholesterol and uric acid based on Table I dan Table II.

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TABLE I
CLASSIFICATION OF CHOLESTEROL

Total Cholesterol	Risk Classification
< 100 mg/dL	Low
< 200 mg/dL (< 5,18 mmol/L)	Ideal
200-239 mg/dL (5,18 – 6,2 mmol/L)	Upper Limit
> 239 mg/dL (> 6,2 mmol/L)	High

TABLE II
CLASSIFICATION OF URID ACID

Normal Value of Uric Acid (mg/dL)	
Man	3,4 – 7,0
Woman	2,4 – 6,0
Child	2,0 – 5,5

The classification stage work for the patients to understand their total health condition. In the classification of obesity using the BMI (Body Mass Index) table equation as in Table III.

TABEL III
CLASSIFICATION OF OBESITY

BMI	Category
< 18,5	Underweight
18,5-24,9	Normal
24,9-29,9	Overweight
>29,9	Obesity

To determine hypoxia disease using the fuzzy logic method. The fuzzy method is suitable for problems with more than one input type or has many inputs. The following Table IV and V are used to decide for hypoxia.

TABLE IV
CLASSIFICATION OF BPM (BEAT PER MINUTE)

Category	Bpm
Low	< 57 Bpm
Normal	60 – 80 Bpm
Hyper	> 83 Bpm

TABLE V
CLASSIFICATION OF SPO2

Category	O2 (%)
Normal	> 95 %
Mild	91 - 94 %
Medium	86 - 90 %
Critical	< 85 %

E. Database

The database in this study is used to store all patient checking activities. So that patients and medical personnel can easily see and check the patient's condition through the patient's medical record. The database used is the MySQL database. The Entity-Relationship Diagram (ERD) Database is used in Figure 10.

The database is an Entity Relationship Diagram (ERD) Database. In the database that has been created, there are five tables, including:

- User Table: A table that contains simple information about patients and is useful for logging into Health Care Kiosk.
- Blood_pressure table: A table containing information on the patient's blood pressure, both systolic and diastolic.
- Blood_sugar table: A table that contains information on the patient's blood sugar, and there are also classification results along with checking times.
- Body_temperature table: A table collecting information on patients who have had their body temperature tested by a healthcare professional. The body temperature of the patient and the classification findings are included in this table.
- SPO2 table: A table that contains information on blood oxygen levels (SPO2), the patient's heart rate, and the classification results that have been made.
- Uric_acid table: A table that contains information on the patient's uric acid level, and there are also classification results that have been made.
- Cholesterol table: A table that contains information on the patient's total cholesterol level and the classification results that have been made.
- Obesity table: A table that contains information on the patient's height and weight and the results of the classification that has been made.

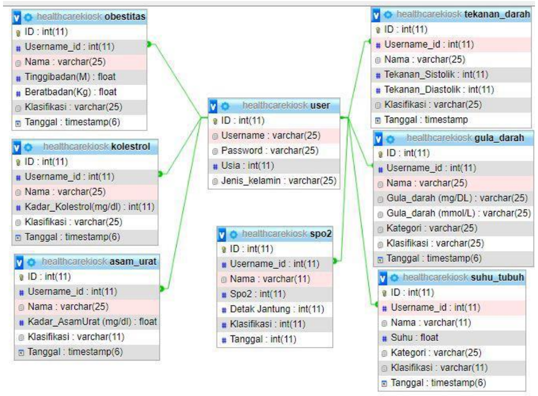

Figure 10. Entity Relationship Diagram (ERD)

F. Data Display

The last stage is to display health data that has been changed according to the previous classification results. In this system, the data is displayed on the Health Care Kiosk screen to understand their health conditions easily. This system uses the Java language to create its Graphical User Interface (GUI) display in Figure 11.

Figure 11. Display Menu Health Care Kiosk

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The results from the two sensors have different values but are still in a state of high uric acid levels, as seen in Figure 12.

Figure 12. Unit Testing Urin Acid Levels

Then, ultrasonic sensors and load cells are also used to detect obesity based on the illustration in Figure 13.

Figure 13. Unit testing Ultrasonic and Load Cell

Ultrasonic sensors are used to measure height, while load cells are used to measure weight. To detect obesity using the BMI table. The Load Cell Sensor used has been calibrated using the HX711 library on Arduino to get a calibration factor by testing the Load Cell by giving a definite load / known weight of goods. The author uses body weight by placing both feet on the load cell and then running the calibration program. On the serial monitor, the weight will appear, then change the calibration factor until it is close to the bodyweight in accordance with the results of the digital scale. The author gets a calibration factor value of 24580, which is then entered into the program to calculate the weight on the Arduino. While for Ultrasonic sensors, calibration is done by limiting the maximum height to 2 meters minus the object distance in Ultrasonic. In this case, the maximum height is reduced by the distance of the patient's head from the sensor so that the patient's height value is then compared with a meter to measure the patient's height. Finally, the SPO2 sensor from MySignal functions to measure the patient's heart rate per minute and oxygen levels in the blood. This sensor is used on the patient's index finger inserted in the SPO2 sensor.

The results above have been calibrated from the factory to buy finished products from the MySignals e-Health Platform. The sensor is connected to the MySignals module by the SPO2 connector. If the results of SPO2 MySignals are compared to those of other brands, the accuracy of SPO2 may be determined (YBK303). Findings from both sensors yield identical numerical results: oxygen saturation is worth 98, and heart rate is worth 97, as illustrated in Figure 14.

Figure 14. Unit testing Device SPO2

III. Result and Discussion

This section describes the research results on checking cholesterol, uric acid, obesity, and hypoxia in a system made on a GUI by comparing other medical devices to determine the percentage of research error. At this stage, the disease is classified based on the health data that has been received. This classification stage has a function so that the system can make a decision whether the patient is normal or there is a disease suffered by the patient such as cholesterol, uric acid, obesity, or hypoxia. The classification stage can also function to understand his total health condition. In the classification of obesity using the BMI table equation (Body Mass Index), while for hypoxia using the fuzzy logic method, the fuzzy method is suitable for problems with more than one type of input or can be said to have many inputs. The result of cholesterol testing can be seen in Table VI.

Table VI
Cholesterol Testing Result

Mission Ultra	Other brand	Error	Error (%)
153	162	9	5.55
180	177	3	1.69
118	128	10	7.81
107	101	6	5.94
134	143	9	6.29
	Error Average:	**7.4**	**5.46**

Based on Table VI above, five tests were carried out and the results of cholesterol sensor testing with amperometric biosensors of other brands, namely, an average error of 5.46%. Getting cholesterol data took about 17 seconds after the blood

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was inserted into the cholesterol strip. Table VII shows the results of comparing the results of the uric acid sensor.

TABLE VII
URIC ACID TESTING RESULT

The Accugence	Other brands	Error	Error (%)
6.5	5.8	0.7	12.07
6.9	7.3	0.4	5.48
6.6	7.1	0.5	7.04
10.4	10.7	0.3	2.80
7.5	7.5	0	0.00
Error Average		0.38	5.33

Following the procedures outlined in Table VII above, five tests were conducted. The results of testing the uric acid sensor with other brands of amperometric biosensors were as follows: there was an average error of 5.33 percent, and it took approximately 15 seconds after the blood was inserted into the uric acid strip to obtain uric acid data. The findings of comparing the data from the obesity sensor are presented in Table VIII.

TABLE VIII
OBESITY TESTING RESULT

Research Device		Other Brand		Error		Error (%)	
Weight	**Height**	**Weight**	**Height**	**Weight**	**Height**	**Weight**	**Height**
51.56	1.71	51.20	1.72	0.36	0.01	0.70	0.58
69.97	1.63	69.88	1.65	0.09	0.02	0.13	1.21
67.15	1.62	66.60	1.61	0.55	0.01	0.83	0.62
86.68	1.68	87.80	1.69	1.12	0.01	1.28	0.59
50.9	1.72	50.40	1.72	0.50	0.00	0.99	0.00
83.24	1.7	82.40	1.68	0.84	0.02	1.02	1.19
66.1	1.63	67.15	1.61	1.05	0.02	1.56	1.24
51.16	1.73	51.20	1.72	0.04	0.01	0.08	0.58
69.45	1.62	69.51	1.65	0.06	0.03	0.09	1.82
87.41	1.67	88.70	1.69	1.29	0.02	1.45	1.18
Error Average:				**0.59**	**0.015**	**0.81**	**0.9**

In Table VIII above, a test is carried out to compare the values of weight and height obtained from Load Cell and Ultrasonic sensors with digital scales and meters. The above test was carried out ten times, resulting in an average error value of 0.81% for the weight value and 0.9% for height. Obtaining weight and height data took about 3 seconds after the user stood in a predetermined place (standing above Load Cell and user's head are under the Ultrasonic sensor). Table 9 is a comparison of the results of the SPO2 sensor, namely oxygen saturation in the blood and heart rate:

TABLE IX
SPO2 TESTING RESULT

Research Device		Other Brand		Error		Error (%)	
SPO2	**Bpm**	**SPO2**	**Bpm**	**SPO2**	**Bpm**	**SPO2**	**Bpm**
97	100	97	101	0	1	0.00	0.99
98	103	98	100	0	3	0.00	3.00
98	95	98	98	0	3	0.00	3.06
98	90	97	90	1	0	1.03	0.00
99	88	98	91	1	3	1.02	3.30
99	101	98	92	1	9	1.02	9.78
98	98	96	100	0	2	0.00	2.00
99	85	96	100	3	15	3.13	15.00
98	101	96	97	2	4	2.08	4.12
92	102	91	113	1	11	1.09	9.73
Error Average:				**0.9**	**5.1**	**0.94**	**5.10**

In Table IX above, a test is carried out to compare the value of oxygen saturation in the blood and heart rate obtained through the MySignal sensor with other brands of Oximeter sensors. A pencil is used to test other oximeters to see whether they are genuine or counterfeit. If the SPO2 value and heart rate are not displayed, then the Oximeter is authentic; if they do appear, it is counterfeit; and vice versa, if the value appears, the Oximeter is genuine. The results of the tests presented above were compared to the original Oximeter. The results of the test table above get an average error of 0.94% for SPO2 and 5.10% for heart rate.

IV. CONCLUSION

Based on the results of system testing, there are some conclusions. First, data retrieval through sensors has a different time. The cholesterol and uric acid levels are taken about 15 -20 seconds, while for Load Cell and Ultrasonic, it is about 3-5 seconds, while for SPO2, it is about 5-10 seconds. Classification for SPO2 uses the Tsukamoto fuzzy logic method. There are two inputs, namely heart rate, and SPO2, so it must be processed using fuzzy logic to get one output of hypoxia classification. Classification of obesity using BMI table. Taking cholesterol and uric acid levels is still an invasive method. Finally, each sensor used in this system has an error (%) of different usage. For the cholesterol sensor, it has an error of 5.46%, for uric acid, it has an error of 5.55%, for load cells, it has an error of 0.81%, for ultrasonic, it has an error of 0.9%, for SPO2 has an error of 0.94%, and heart rate has an error of 5.10%. Furthermore, for the development of this application, you can add several sensors to do other health checks, such as sensors to check Triglycerides, HDL, and LDL to check cholesterol, where this system can only check total cholesterol. In addition, it can be developed by changing all sensors that are still invasive to non-invasive without injuring the patient.

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