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Prototype of blood sugar measuring instrument with non invasive method using near infrared

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ABSTRACT

At present the measurement of blood sugar still uses an invasive tool, this disrupts the patient's comfort and can cause infection and pain. So that a non-invasive tool is needed to measure blood sugar. Tool testing was done by measuring blood sugar levels in 35 patients and seeing a correlation between the value of blood sugar levels with ADC. The test results showed that the value of changes in blood sugar levels followed y = -0.146x + 164.89 Coefficient value R = 0.9233 The value of the accuracy of the tool was 91.086% and the precision of 94.3026%. Blood sugar measuring devices that have been designed to monitor the blood sugar of users by using the internet. This blood sugar meter cannot be used as a reference for the actual blood sugar level. However, the realization of this tool can still determine a rough estimate of the high and low levels of sugar in the blood.

ABSTRAK

Saat ini pengukuran gula darah masih menggunakan alat yang invasif (masuk ke jaringan tubuh), hal ini mengganggu kenyamanan pasien dan dapat menyebabkan infeksi dan nyeri. Sehingga diperlukan alat non-invasif untuk mengukur gula darah. Pengujian alat dilakukan dengan mengukur kadar gula darah pada 35 pasien dan melihat korelasi antara nilai kadar gula darah dengan ADC. Hasil pengujian menunjukkan bahwa nilai perubahan kadar gula darah diikuti y = -0,146x + 164,89 Nilai koefisien R = 0,9233 Nilai akurasi alat sebesar 91,086% dan presisi sebesar 94,3026%. Alat pengukur gula darah yang telah dirancang untuk memantau gula darah pengguna dengan menggunakan internet. Pengukur gula darah ini tidak dapat digunakan sebagai referensi untuk kadar gula darah yang sebenarnya. Namun, realisasi alat ini masih dapat menentukan perkiraan kasar tinggi rendahnya kadar gula dalam darah.

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1. Introduction

Based on the Global status report on NCD, the World Health Organization (WHO) reported in 2010 that 60% of the causes of death of all ages in the world are due to non-communicable diseases. Diabetes mellitus is one of the non-communicable diseases which ranks 6th as the cause of death [1]. Diabetes is one of the biggest causes of death in Indonesia. The 2014 Sample Registration Survey data showed that Diabetes was the third largest cause of death in Indonesia with a percentage of 6.7%, after stroke (21.1%) and coronary heart disease (12.9%) [2].

Some ways that can be used to measure blood sugar levels. Each measurement technique has advantages and disadvantages. The sugar measurement technique in general is divided into two methods, namely the Invasive method and the Non-Invasive method. [3-11] The invasive method is a method that is widely used to determine blood sugar levels by using a patient's blood sample, the lack of this method is the presence of pain due to blood sampling by injuring the patient's body parts. By injuring the body it can cause infection, the infection occurs because the body of diabetics is unable to produce insulin. Insulin is very important in the process of absorption and processing of glucose in the body's cells to produce energy well. Therefore, a Non-Invasive method is needed to measure blood sugar levels. The Non-Invasive method, is a measurement technique that can be done without injuring the patient by utilizing light as a medium.

Based on the background that has been described Non-invasive blood sugar measurement tools using Near infrared is the solution to these problems. The results of the blood sugar measuring device will be displayed on the smartphone and LCD, the Android application is made to display and store glucose

values measured together with the date, time in a text file that can be seen at any time. With practical and comfortable, and has an accuracy as good as an invasive method.

2. Research Method

The method used in this study can be seen in Figure 1 using a non-invasive method, and this tool uses near infrared as a transmitter and photodiode is used as a receiver. The finger is used as a measurement sample.

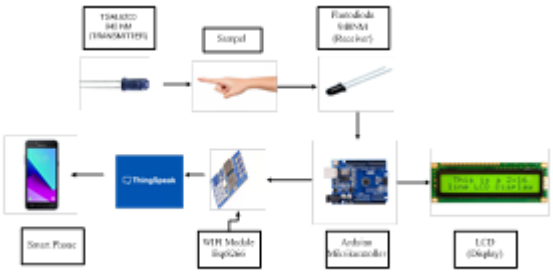

Figure 1. Block diagram of blood sugar measuring instrument

Figure 1 shows a block diagram of a blood sugar measuring instrument consisting of several blocks including infrared as a transmitter, photodiode as a receiver, Wifi Module and LCD, smartphone as a medium for monitoring the results of measuring blood sugar,

Infrared and photodiode in this system are used as light emitters to illuminate the object being analyzed, namely the finger. The light emitted by the source will pass through the finger before reaching the photodiode. When passing through the finger there are factors that affect the light received by the photodiode. One of them is glucose molecules in the blood. From the molecular factor of the blood sugar molecule, there will be a change in the intensity of light received by the photodioda. So that the sensor output in the form of an analog voltage will be processed in the microcontroller to get the ADC (Analog Digital Converter) value, the ADC is converted into a blood sugar value and the results of the measurement will be displayed on the 2X16 LCD layer. Wifi module is used to send data to the internet, in this research using thingspeak as a storage media (cloud), then sent to the smarthphone application in the form of a graph of the patient's blood sugar measurement history.

2.1. Design Hardware

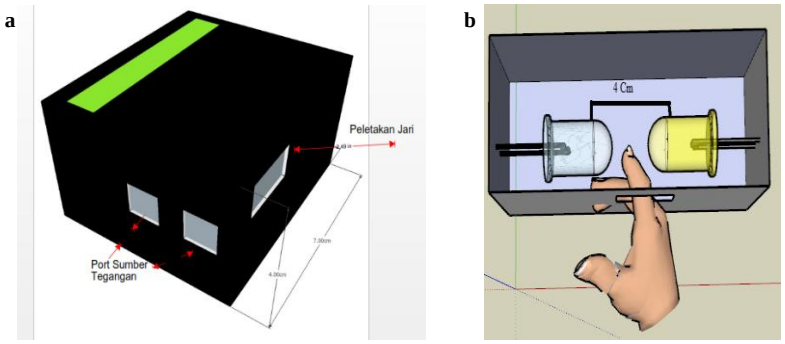

Figure 2. (a) and Figure 2 (b) Design Hardware

Seen in figure 2 (a) the sensor design is installed in the black box where Infrared light is emitted parallel to the photodiode sensor. This box will later be the place where the finger is placed to measure the sugar content. The finger will be placed between the photodioda and infrared like Figure 2 (b), the amount of light intensity that has passed through the finger which will later be converted into the form of blood sugar levels.

Making a blood sugar measuring system begins with the design of the model. Figure 3 is a specification of the size of the box, and the placement of the design sensor is made of boxes and has a length of 6 cm, width of 7 cm and height of 4 cm, size is made small because it makes it easier for users to carry this tool. Figure 3 shows the hole for the patient's finger to be measured. And this tool uses a power supply from a USB port of 5 volts or uses 9 Volt power supply that is included in the Arduino port.

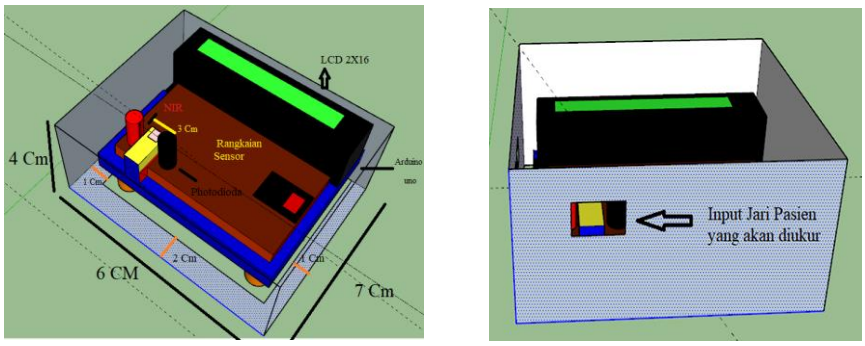

Figure 3. Sesificatio Design Hardware

2.2. Design of Work Flow Blood Sugar Measuring Instrument

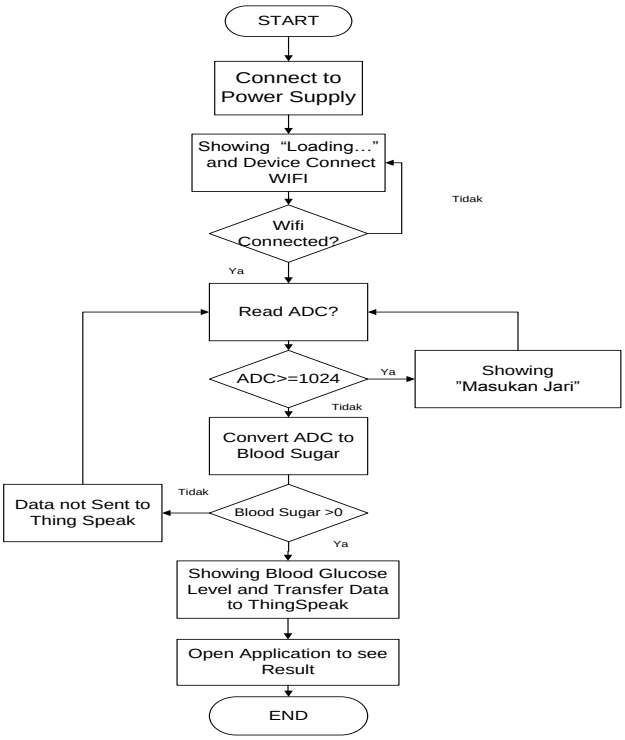

Figure 4. Design of Work Flow Blood Sugar Measuring Instrument

Design work flow in this study can be seen with a flowchart that has been made like Figure 4 Flowchart is used to explain the stages carried out by this design tool. First the LCD displays the word loading, the word loading is used as an interface only, that this tool cannot be ready to use, because it enters the process of connecting to wifi. If the device is able to connect to wifi then it enters the next process, otherwise it returns to the process of connecting the wifi again. The next process is reading the ADC by the microcontroller, if the ADC> = 1024 then displays "Finger Input" if not, then convert the ADC into blood sugar, and if blood sugar> 0 then the results will be displayed in the LCD and also send data to thingspeak. If not, the data is not sent and returns to the reading process of the ADC again. The data sent can be seen by opening the android application that has been designed and can be seen as a result of the measurement of blood sugar. Finished.

3. Result and Analysis

The research that has been done gets the results and discussion as follows. In the results of this discussion it contains the results of application design and result of measurement of blood sugar levels.

3.1. Test Result for Android Apliations

Table 1. Result Android Applications

Smarthphone	Screen Size (inch)	Android Version	Pixels	Result
Samsung J1 MINI	4	Lolipop	800x400	Work
Samsung J7 PRO	5.5	Nougat	1.920 x 1.080	Work
Samsung A5	5.2	Oreo	1.920 x 1.080	Work
Samsung J5	5.2	Marsmellow	1280 x 720	Work
Xiaomi 5a	5	Nougat	1280X1080	Work
Xiaomi Redmi 5a	5	Nougat	1280X1080	Work
Xiaomi 4C	5.1	Lolipop	1080 x 1920	Work
Samsung A6	5.6	Oreo	1480x720	Work
Samsung J2 Prime	5	Marsmellow	960 x 540	Work
Oppo F1s	5.5	Nougat	1080 × 720	Work

Table 1 shows the performance of the application that has been designed, the results show that the application can be said to work well except for the Samsung j1 mini smartphone. The Smarthphone cannot display interfaces poorly due to the small screen, but the application can run well. Based on the tests carried out it can be said that the android applications that have been designed are said to be successful, both in terms of interface and program.

3.2. Results of measurement of blood sugar levels

The overall test is done by comparing the design tool so that it can know the value of accuracy and accuracy. Testing is done by measuring blood sugar levels from patients using a NESCO multicheck design tool. Measurements were made three times. The value of accuracy is obtained by entering the value of the blood sugar level of the design tool and the blood sugar level of NESCO multicheck on each measurement later, from all the values of accuracy and the accuracy of the data calculated. Based on the calculation results presented in Table 2, the average accuracy of the tool is 91.086% and the average accuracy of the tool is 94.3026 %.

Table 2. Result Comparing with NESCO Multicheck

Probandus	Result Design	Nesco	Standar Deviasi	Acuracy	Precision
	95			100	98,59
1	94	95		98,95	
	88		1.3	93	
	116			92,8	97,47
2	118	122		94,5	
	123		3	98,4	
	102			98	99,34
3	104	100		96	
	98		0.66	98	
	115			88	96,72
4	124	130		95,38	
	127		4	97,69	
	88			83,8	98
5	115	105		90,47	
	100		2	95,37	
	170			80	86
6	176	214		83	
	164		4,9	78	
	174			87	84
7	164	200		82	
	164		8,1	82	
			Avarage	91,08676	94,3026

The measurement results indicate an error value, this is due to many factors such as movement and inaccurate insertion of the patient's finger when measurements affect the reading results, and measurements 6 and 7 use different equations because patients have very high blood sugar values. Measurement of blood sugar with the largest comparison with an error of 20% and the smallest value of 1.95%.

4. Conclusion

Based on the research that has been done, conclusions can be drawn as follows:

1. It has been successfully made a non-invasive measuring device for blood glucose levels with a calibration method using linear regression and the lowest error value of 2%
2. The design results in this study obtained accuracy of 94% and accuracy of 91% by using the equation that has been obtained $y = -0.146x + 164.89$ $R^2 = 0.9223$ by taking data as many as 35 probands
3. Android applications can work properly and data can be successfully sent by ESP8266. Patients can monitor the results of their blood sugar measurements.
4. The results of calculating the percentage of tool errors can be seen that the percentage error value is quite large. So that the realization of a blood sugar measuring device cannot be used as a reference for the actual blood sugar level. However, the realization of this tool can still determine a rough estimate of the high and low levels of sugar in the blood.

This study has several suggestions for further research to get better results. The placement of the sensor must be precise and unchanging, because it can affect the value of the ratio obtained, and also multiply the sample, the more samples the more precise the measurement of blood sugar levels

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