Measurement device for detecting oxygen saturation in blood, heart rate, and temperature of human body

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Measurement device for detecting oxygen saturation in blood, heart rate, and temperature of human body

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Abstract. The progress of science and technology must be able to help solve human medical problems for human survival. In this study, integrated measurement of oxygen saturation in the blood, heart rate and temperature of the human body have been made into one tool whose measurement results are displayed directly on the LCD display on a measuring instrument and an Android Smartphone. This tool uses Arduino Nano as its Microcontroller, Bluetooth as wireless serial communication with Android smartphone, Android Application Made with MIT App Inventor, MAX30100 sensor is used to measure blood oxygen saturation and heart rate, and MLX90614 sensor to measure body temperature. Testing Measurements that have been made are calibrated with Industrial standard measuring instruments (Oximeters) and digital thermometers. The result is that the accuracy of the tool reaches 99.62% for blood oxygen saturation measurements, 97.55% for heart rate, and 99.62% for body temperature when compared with industry standard devices. Android applications have been successfully installed on 5 types of smartphones with different brands and specifications. The Bluetooth range of a measuring device for a smartphone in maximum data transfer is 29 meters without a hitch and a maximum of 21.5 meters with obstacles.

1. Introduction

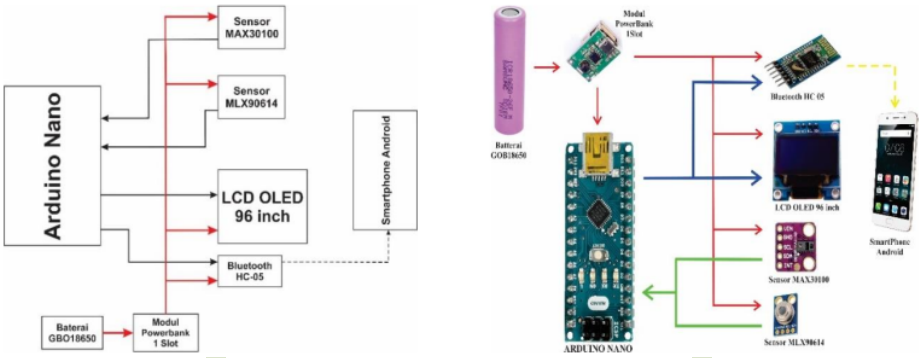
Health is a human right and one of the elements of welfare that must be realized in accordance with the expectations of the Indonesian nation as the UUD 1945 Constitution [1]. It should be noted that the human brain will consume 20% of the oxygen inhaled and if this is hampered by eating will have an impact on the weakening of other organs and have an impact on the emergence of hypoxia. Please note that normal blood oxygen saturation ranges from 80-100% [2]. Therefore, the need to maintain oxygen levels in the blood in the body [3]. In addition, humans are also required to maintain their heart condition because the heart is also an important organ of the body. Heart disease is ranked first as the cause of one's death [4], therefore the condition of the heart must be monitored, one of which is to monitor the condition of a normal pulse ranging from 60-100bpm. In addition to the importance of monitoring oxygen saturation, and the heart rate of the human body, monitoring human body temperature is also very important, especially in young children. In 2001 the World Health Organization (WHO) classified Indonesia in category A in the identification of dengue fever (DB), this indicates that the number of hospital care and deaths caused by fever is very high.

At present several generations of residents in Indonesia have developed digital oximeter technology equipped with a buzzer for indicators that reminds if there is a decrease in oxygen saturation in human blood [2]. In addition, human heart rate monitoring has also been developed by attaching a pulse sensor to the fingertips of a human hand on a measuring instrument that has been made and displaying the results of the measurements on the measuring instrument display.

Based on the problems and results of previous studies, then in this study, integrated measurement of oxygen saturation, heart rate and body temperature in this study have been developed. This tool is made and packaged in a portable, mini, and can be connected with an Android smartphone using Bluetooth communication [5]. This tool is also equipped with battery charging media so that if the battery runs out can be refilled without having to replace the battery. For the use of this measuring instrument can be done by attaching one of the fingers on the sensor that has been provided, then easily the three parameters of the gauge will appear on the LCD and Android smartphone.

2. Method

This tool will use two sensors that serve to retrieve patient data by using the media of one finger. For more details, can be seen in Figure 1 block system diagram.



(a) (b)

Figure 1. (a) Block system diagram, (b). Illustration of the design of measuring instruments in this research and supporting sensors.

Figure 1 (a) is a block diagram that shows the outline of the measuring instruments developed in this study. The microcontroller used for overall instrumentation control is Nano, Arduino. The sensors used are as many as two, namely the MAX30100 sensor to measure oxygen saturation in the blood and heart rate, with the method of cooling only enough to attach the fingertips to the sensor [6,7]. To measure body temperature using the MLX90614 sensor, this sensor utilizes infrared as data retrieval of the object, so that temperature measurements can be made only by holding the body or fingers closer to the sensor. The measurement results are displayed on the 0.96 inches OLED LCD display and are also displayed on an Android smartphone. Transfer data from measuring devices to smartphones using Bluetooth communication HC-05. Instrumentation measuring instruments made are equipped with batteries and the Power bank module is portable and can be recharged if the battery runs out, so there is no need to replace the battery. Android applications on smartphones are made using MIT App Inventor and can be installed on any Android smartphone. The android application is designed to display the value of the measurement results on a smartphone. Testing Measurements that have been made are calibrated with an industry standard measuring instrument (Oximeter) and a digital thermometer. Calibration results are used to compare the accuracy of the measuring instruments that have been made to industry standard measuring instruments sold in the market. Testing the maximum limit of Bluetooth communication distance measuring devices that have been made on smartphones is done by giving a variable distance

between different test distances, different types of smartphones, and the presence or absence of obstacles.

3. Results and discussion

In this section we will review some of the results of testing the accuracy of the MAX30100 sensor (measuring oxygen saturation in the blood and heart rate) against Industry standard measuring instruments (Oximeter), Testing the accuracy of the MLX90614 Sensor (measuring body temperature) against Industrial standard measuring devices (digital thermometers), and testing at some maximum distance Bluetooth performance sends information on measurement results to a Smartphone.

3.1. Test on sensor accuracy detection of oxygen saturation and heart rate (MAX30100)

Tests on the accuracy of the Oxygen Saturation detection sensor (Table 1) and Heart Rate (Table 2), each of which is tested for its accuracy value, and carried out as many as 5 tests in patients who are different. Test results that have been obtained are then compared with the industry standard measuring instruments (Finger Oximeter (FO)) to obtain the level of accuracy of the measuring instrument.

Figure 2. Tests on the accuracy of sensors detection of oxygen saturation in blood.

Figure 3. Testing the accuracy of body temperature sensors (MLX90614) against temperature measuring devices (Infrared Thermometer (IR60)).

Table 1. Tests on the accuracy of sensors detection of oxygen saturation in blood.

Name & Age	Average Oxygen Saturation		Deviation	Standard Deviation Oxygen Saturation		Accuracy
	MAX30100 (%)	FO (%)		MAX30100	FO	MAX30100 (%)
Fariz (18 years)	94	96.6	2.6	0	1.94936	97.23
Rizal (22 years)	94.2	97	2.8	0.44721	1	97.03
Dani (21 years)	94.4	96.6	2.2	0.54772	1.67332	97.67
Suparmi (46 years)	94.2	97.2	3	0.44721	0.83666	96.82
Sumarli (49 years)	94	97.6	3.6	0	1.14018	96.17

From Table 1. it was found that the results of the Testing on the accuracy of the sensor detection of Oxygen Saturation in the Blood ranged from 96.17% - 97.67% when compared to Industrial standard measuring instruments (Finger Oximeter (FO)), with a standard deviation value of 0.83 - 1.94, and deviation values the results range from 2.2 - 3.6. This shows that the accuracy of the sensor on the device

that has been made is quite maximal and almost close to the value displayed by the industry standard tool, and the stability of performance on the equipment that has been made is also quite stable, as evidenced by the small standard deviation value. Non-invasive oxygen saturation measurements are based on the principle that blood in the arterial vein absorbs light as a pulse, and the status of the pulse wave is reflected by changes in the amount of light absorption [7,8].

Table 2. Tests on the accuracy of the heart rate detection sensors.

Name & Age	Average heart rate	Average heart rate	Deviation	Standard Deviation heart rate		Accuracy heart rate
	MAX30100 (bpm)	FO (bpm)		MAX30100	FO	MAX30100 (%)
Fariz (18 years)	96.05	103.4	7.35	6.153	7.403	92.35
Rizal (22 years)	75.314	75.2	0.114	4.089	1.643	99.65
Dani (21 years)	75.548	76	0.45	2.836	2.345	99.40
Suparmi (46 years)	92.6	92.2	0.4	4.842	2.864	99.57
Sumarli (49 years)	62.138	60.2	1.938	3.4	1.304	96.78

Based on Table 2, it was found that the Test results on the accuracy of sensor detection of heart rate ranged from 92.35 bpm - 99.65 bpm when compared to Industrial standard measuring instruments (Finger Oximeter (FO)), with a standard deviation value of 1.30– 7.40, and a deviation value produced ranging from 0.11 - 7.35. This shows that the accuracy of the sensor on the device that has been made is quite maximal and almost close to the value displayed by the industry standard tool, and the stability of performance on the equipment that has been made is also quite stable, this is evidenced by the small standard deviation value. Based on Table 2, it was also found that the patient's data or object that measured his heart rate ranged from 92.35 bpm - 99.65 bpm, it showed a heartbeat under normal conditions [9,10].

According to the American Heart Association, a slow heart rate can imply that heart function works efficiently. This is evident in the average heart rate that athletes have when relaxing, which ranges from 40-60 BPM. It's just that when someone likes to exercise and has a weak heart rate (below 60 bpm), then it can be a sign of a problem in the heart's electrical system (bradycardia). bradycardia means that a natural pacemaker cannot work properly or the heart's electrical pathway is disrupted. If this is allowed, it can disrupt the function of the heart as pumping blood, so that the blood needs of the body cannot be fulfilled properly.

3.2. Test for body temperature sensors (MLX90614)

Tests on body temperature accuracy (Table 3.) of humans using the MLX90614 sensor were carried out 5 times in different patients. Test results that have been obtained are then compared with the industry standard measuring instruments (Infrared Thermometer (IR60)) to obtain the level of accuracy of the measuring instrument.

Table 3. Testing the accuracy of body temperature sensors (MLX90614) against temperature measuring devices (Infrared Thermometer (IR60)).

Name & Age	**Average body temperature**		**Deviation**	**Standard Deviation body temperature**		**Accuracy**
	MLX90614 (ºC)	**Thermometer (ºC)**		**MLX90614**	**Thermometer**	**MAX30100 (%)**
Fariz (18 years)	33.97	34.04	0.07	0.44878	0.61482	99.79
Rizal (22 years)	32.98	33	0.02	1.03059	1.06536	99.39
Dani (21 years)	33.61	33.74	0.126	0.46549	0.72664	99.63
Suparmi (46 years)	33.65	33.74	0.086	0.32261	0.23022	99.73
Sumarli (49 years)	34.53	34.68	0.148	0.19188	0.29496	99.57

From Table 3. it was found that the Test results on the accuracy of the sensor detection of human body temperature ranged from 99.37 ºC - 99.79 ºC when compared to Industrial standard measuring

instruments (Thermometer Infrared (IR60)), with a standard deviation value of 0.32– 1.03, and a deviation value the yield ranges from 0.02 - 0.14. This shows that the accuracy of the sensor on the device that has been made is quite maximal and almost close to the value displayed by the industry standard tool, and the stability of performance on the equipment that has been made is also quite stable, this is evidenced by the small standard deviation value.

3.3. Maximum Bluetooth distance testing

Bluetooth distance testing is carried out in the electrical engineering laboratory of the University of Muhammadiyah Sidoarjo with provisions consisting of different test distance variables, different space variables, and variables with the presence of a barrier or the absence of a barrier (figure 4). Testing is done using 4 different types and specifications of smartphones that are different from one another. Each smartphone is carried out at least 5 trials which are influenced by variables such as distance, space, and obstruction.

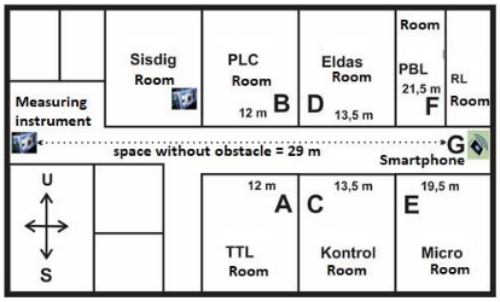


Figure 4. Plan of the position of the measuring instrument for the smartphone, in order to test the maximum distance of working Bluetooth measuring instrument against the Android Smartphone.

Table 4. Maximum Bluetooth distance testing.

Specification of Smartphone Android	No	Room							Average	Standard Deviation
		A (12m)	B (12m)	C (13.5m)	D (13.5m)	E (19.5m)	F (21.5m)	G (29m)		
Samsung Galaxy V, OS Android v4.4.2 (KitKat), CPU = 1.2 GHz, Bluetooth version v4.0, A2DP	1	1	1	1	1	0	0	1	0.714	0.48795
	2	1	1	1	1	0	0	1	0.714	0.48795
	3	1	1	1	1	0	0	1	0.714	0.48795
	4	1	1	1	1	0	0	1	0.714	0.48795
	5	1	1	1	1	0	0	1	0.714	0.48795
Lenovo 6010, OS Android v5.1 (Lollipop), CPU = Quad-core 1.2 GHz Cortex-A53, Bluetooth v4.2,	1	1	1	1	1	0	0	1	0.714	0.48795
	2	1	1	1	1	0	0	1	0.714	0.48795
	3	1	1	1	1	0	0	1	0.714	0.48795
	4	1	1	1	1	0	0	1	0.714	0.48795
	5	1	1	1	1	0	0	1	0.714	0.48795
Samsung Galaxi A5 OS Android v6.0.1 (Marshmallow), CPU = Quad-core 1.2 GHz Cortex-A53, Bluetooth), A2DP, EDR, LE	1	1	1	1	1	1	0	1	0.857	0.37796
	2	1	1	1	1	1	0	1	0.857	0.37796
	3	1	1	1	1	1	0	1	0.857	0.37796
	4	1	1	1	1	1	0	1	0.857	0.37796
	5	1	1	1	1	1	0	1	0.857	0.37796
Vivo Y69, OS Android v7.0 (Nougat), CPU = Octa-core 1.5 GHz Cortex-A53, Bluetooth v4.2, A2DP, LE	1	1	1	1	1	1	0	1	0.857	0.37796
	2	1	1	1	1	1	0	1	0.857	0.37796
	3	1	1	1	1	1	0	1	0.857	0.37796
	4	1	1	1	1	1	0	1	0.857	0.37796
	5	1	1	1	1	1	0	1	0.857	0.37796

Space description of Table 3.:
A = Electric Power Engineering Room (12 meters)
B = PLC Room (12 meters)
C = Control System Room (13.5 meters)
D = Basic Electronics Room (13.5 meters)
E = Microcontroller Room (19.5 meters)
F = Electricity Measurement Room (21.5 meters)
G = No Obstacles (Corner to Corner) (29 meters)

Data Description for table 3.3 :
0 = Not Connected (Disconnected)
1 = Connected

From distance testing that has been done in Table 3, it can be concluded that Bluetooth can be used for wireless serial communication with a maximum distance of 19.5 meters with minimal specifications on Samsung Galaxy A5 smartphones (2015), for specifications below the maximum is only 13.5 meters.

4. Conclusion

Measuring Instrument Oxygen Saturation in Blood, Heart Rate, and Human Body Temperature Based can work well and optimally. Testing Measurements that have been made are calibrated with Industrial standard measuring instruments (Oximeters) and digital thermometers. The result is that the accuracy of the tool reaches 99.62% for blood oxygen saturation measurements, 97.55% for heart rate, and 99.62% for body temperature when compared with industry standard devices. Android applications have been successfully installed on 5 types of smartphones with different brands and specifications. The Bluetooth range of a measuring device for a smartphone in maximum data transfer is 29 meters without a hitch and a maximum of 21.5 meters with obstacles.

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