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The Design of Wireless Medical Devices with Multi-sensor Using Android and iOS-Based Smartphone Displays

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Abstract

In this study, a multisensor wireless medical device was designed using several sensors, such as body temperature, oxygen levels, blood pressure, and heart rate, that connects to the application and applies WBAN technology. The design of this tool applied the principle of IoT, where a system that can monitor body health is needed, a remote monitoring system on the smartphone. The data obtained by the tool is sent to the server to be later forwarded to the application. In this study, Fuzzy Mamdani's method was used to implement the health status. The IoT principle makes it effortless for users to access or use pre-designed tools. Therefore, in this study, the IoT principle is employed to make it more efficient and easier for users to read the results because the data will be forwarded to applications installed on users' smartphones, both Android and iOS-based.

Keywords*:* Monitoring System, WBAN (Wireless Body Area Network), IoT (Internet of Things), Android, iOS

Abstrak

Penelitian ini merancang alat kesehatan wireless multisensor menggunakan beberapa sensor seperti sensor suhu tubuh, kadar oksigen, tekanan darah, dan detak jantung yang akan terhubung dengan aplikasi dan menerapkan teknologi WBAN. Perancangan alat ini menerapkan prinsip IoT di mana diperlukan suatu sistem yang dapat memantau kesehatan tubuh yang disebut dengan sistem pemantauan jarak jauh pada smartphone. Data yang diperoleh alat dikirim ke server untuk kemudian diteruskan ke aplikasi. Pada penelitian ini, metode Fuzzy Mamdani digunakan untuk mengimplementasikan status kesehatan tersebut. Prinsip IoT sangat memudahkan pengguna untuk mengakses atau menggunakan alat yang telah dirancang sebelumnya. Oleh karena itu, dalam penelitian ini, penerapan prinsip IoT dilakukan agar lebih efisien dan mudah bagi pengguna untuk membaca hasilnya karena akan diteruskan ke aplikasi yang terpasang di smartphone pengguna, baik berbasis Android maupun iOS.

Kata-kata kunci*: Sistem Pemantauan, WBAN (Wireless Body Area Network), IoT (Internet of Things), Android, iOS*

1. Introduction

Currently, conducting a general medical check-up as an early step to figure out the health condition is increasingly being carried out. The purpose of this medical check-up is to detect what diseases someone is experiencing or to find out a person's health at the time [1]. Healthy lifestyles to achieve fitness are numerous, and to achieve optimal vigor requires a tool to know that health status [2]. The motivation to do this medical check-up consists of several factors, including particular prerequisites as part of administration, also personal awareness to monitor body condition [3]. One of the technologies used in medical check-ups is WBAN (Wireless Body Area Network).

This wireless communication technique is applied in the field of health that can be said to be a paramount technology to monitor a person's health condition [4]. In addition to being carried out in the health examination room, currently, the health checking activities have been carried out independently. WBAN technology places sensors inside, around, and on the surface of the human body [5]. It aims to detect vital signs from within the patient's body, such as checking body temperature, blood pressure, oxygen levels, and heart rate [6]. Examination using WBAN technology is expected to reduce mortality by advanced detection with sensors in patients [7]. Health is the most valuable asset, so health issues are a preponderant aspect everyone needs to pay attention to [8].

The tool also allows health staff to check the patient's condition and access it from Android and iOS-based smartphones. The android platform is a software platform for smartphones that can also be distributed publicly or, commonly, open source [9]. The creation of this tool uses a space-friendly hardware system and can solve problems such as remote health checks and costs from healthcare in real-time [10]. Classifying the health status of patients requires the help of Artificial Intelligent (AI) [11]. One of the fields using AI is fuzzy logic, a way to map input problems to desired outputs [10].

The description is the reason behind designing a medical device integrated with a number of sensors, namely body temperature, blood pressure, heart rate, and oximeter. This tool is enhanced with a simpler size, is easy to use, portable, and has monitoring features through the display of Android and iOS smartphones.

2. Method

a. Material

1) ESP8266 NodeMCU Module

NodeMCU is an electronic board based on the ESP8266 chip that can perform microcontroller functions and internet connectivity (WiFi). NodeMCU ESP 8266 has a USB port (mini-USB) that makes programming easier [12].

2) Android Operating System

Android is a technology based on the Linux kernel to support device performance and is open source. Therefore, this operating system has been migrated to smartphones [13].

3) iOS Operating System

This technology was developed by Apple Inc. and was introduced in 2007. The device's built-in accelerometer works for rotation in three dimensions (such as switching from portrait to landscape mode) as well as responding to device shocks.

b. Method

1) Hardware Design

At this stage, the design of hard equipment on a multisensor wireless medical device using a smartphone was illustrated through a system block diagram so that an overview of the tool can be estimated.

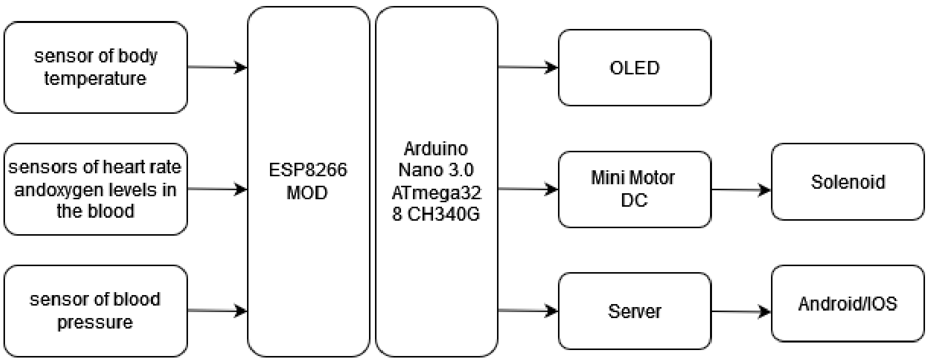

Figure 1. Hardware System Diagram Block

As depicted in Figure 1, this body health monitoring system is designed using ESP8266 MOD and Arduino nano which consists of various sensors. This sensor also functions as a means of checking the health of vital signs in the patient's body. These sensors include the MLX90614 sensor used in the body temperature sensor, the MAX 30100 sensor used in sensors of heart rate and oxygen levels in the blood, and the AP3 models' blood pressure sensor used in blood pressure sensors in the body. The ESP8266 functions as a microcontroller on each sensor connected to the wifi network. The data read by the sensor enters the server, then it will be displayed on the smartphone via Android or iOS.

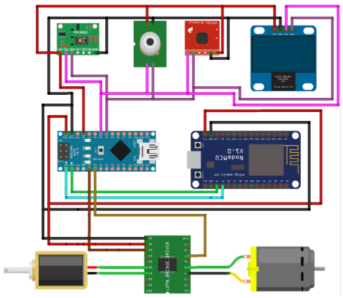

Figure 2. Overall Circuit Scheme

Figure 2 is a schematic of the overall circuit design constructed using components from the hardware. It consists of several sensors, such as the MAX 30100 sensor for oxygen levels in the blood and heart rate, the MLX 90614 sensor as a body temperature sensor, and a blood pressure sensor AP3 models.

2) Software Design

At this stage, the preparation of programming algorithms that will be run by the system was carried out, starting from processing sensor input data to presenting data results on OLED displays and smartphones in real-time.

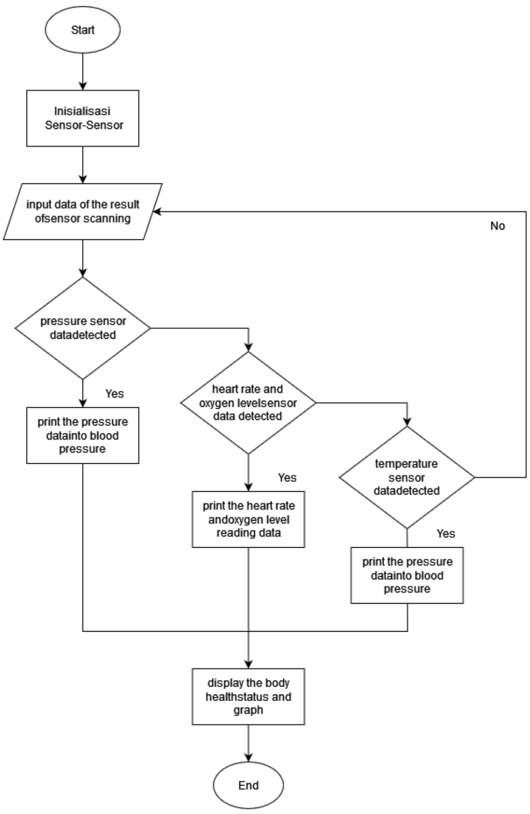

Figure 3. Flowchart Software

The flowchart in **Figure 3** shows that the program flow begins with the initiation of the sensor inputs used. The next stage is processing the input data of each sensor by scanning the sensor data at each sensor pin address. If the data of each sensor is successfully detected, the process continues by data sending from the readings of each sensor through the command to data print of the sensor readings.

3. Results and Discussion

From the designing and testing wireless medical devices with Android and iOS-based multisensors, the results of hardware design and test data from several patients were obtained. They are elaborated as follows.

1) Hardware Design Results

The result is hardware designed using a specific application and printed hardware box to protect other components and sensors from damage by using the 3D printing method that helps to visualize objects with decisive details. In addition, this 3D printing technique can make the appearance of the hardware box more attractive.

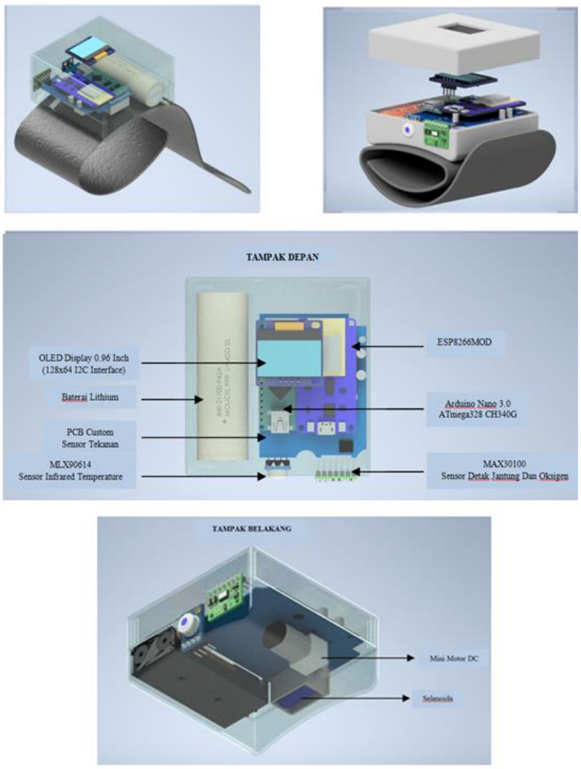

Figure 4. 3D Printing Design

(a) **(b)** **(c)**

Figure 5. (a) Hardware Outer Top View (b) and (c) Hardware Side View

2) Data Testing Results

The test was carried out to determine the patient's health using a wireless medical device with a multisensor that had been tested. During testing, the tool retrieved data by applying three age categories, namely adolescents (18-25 years), adults (26-55 years), and the elderly (>56 years and above). Then, the reading results from the health check are sent to the server, processed, and displayed via smartphone using Android and iOS in real-time.

Tabel 1. Data on Testing Results of Wireless Medical Devices with Multisensors in Adolescents

No	Age	Hour	Temp (°C)	Heart Rate (BPM)	SPO2 (%)	Systolic (mmHg)	Diastolic (mmHg)	Gender	Status	Duration (seconds)
1.	18	15.05	36	85	95	125	80	P	Healthy	45.72
2	18	15.07	36	89	95	124	76	P	Healthy	36.51
3	21	15.09	36	106	96	106	85	P	Healthy	30.29
4	21	15.11	35	92	95	104	74	P	Healthy	38.28
5	21	15.14	35	132	95	105	73	P	Needs Action	37.97
6	20	15.18	35	96	95	142	106	L	Needs Action	1.09.53
7	21	15.20	37	89	95	135	99	L	Needs Action	1.00.45
8	20	15.23	37	78	95	108	79	P	Healthy	43.10
9	21	15.25	37	83	95	100	70	P	Healthy	41.63
10	21	15.29	36	82	95	113	85	P	Healthy	39.67
11	21	15.31	36	81	95	135	106	L	Butuh tindakan	50.42
12	20	15.33	36	79	96	97	76	P	Healthy	55.10
13	20	15.35	36	91	96	95	66	P	Healthy	50.49
14	20	15.37	36	70	96	96	77	P	Healthy	42.19
15	20	15.41	37	93	96	98	79	P	Healthy	43.54
16	20	15.43	37	84	96	108	80	P	Healthy	49.50
17	21	15.45	36	95	95	108	79	P	Healthy	37.73
18	20	15.53	37	95	95	105	75	P	Healthy	56.20
19	21	15.51	37	77	95	140	121	L	Needs Action	48.14

20	21	15.48	36	112	95	142	104	P	Needs Action	1.01.21
21	21	15.55	37	93	96	110	77	P	Healthy	48.20
22	20	15.57	37	86	95	111	79	P	Healthy	46.65
23	18	15.59	37	87	96	108	77	P	Healthy	51.67
24	18	16.02	37	95	96	104	77	P	Healthy	56.66
25	22	16.05	37	74	96	103	71	P	Healthy	44.31
26	24	16.07	37	92	96	104	72	P	Healthy	44.12
27	24	16.09	36	92	95	104	72	P	Healthy	37.83
28	18	16.12	37	96	95	106	82	P	Healthy	44.04
29	18	16.14	36	98	95	104	79	P	Healthy	50.30
30	21	16.17	36	66	95	100	66	P	Needs Action	40.49

Table 1 shows data from the examination of wireless medical devices with multi-sensors in 18–25-year-old adolescents. Thirty people were tested for health in the afternoon. The data shows 23 adolescents (76.6%) with "healthy" health status, seven adolescents (30.4%) with "need action" health status, and 0 adolescents with "symptomatic" health status.

Table 2. Data on Test Results of Wireless Medical Devices with Multisensors in Adults

No	Age	Hour	Temp (°C)	Heart Rate(bpm)	SPO (%)	Systolic (mmHg)	Diastolic (mmHg)	Gender	Status	Duration (Seconds)
1	27	09.20	36	72	95	125	85	L	Healthy	40.12
2	26	09.23	36	84	95	149	98	L	Needs Action	45.39
3	39	09.25	36	83	96	135	87	L	Healthy	38.12
4	31	09.27	37	72	95	132	90	L	Healthy	33.35
5	30	09.29	37	98	95	127	85	L	Healthy	35.12
6	28	09.30	36	106	96	148	98	L	Needs Action	40.43
7	26	09.32	36	80	96	130	85	L	Healthy	42.30
8	26	09.34	36	91	95	124	83	L	Healthy	44.16
9	50	09.37	37	83	95	176	114	L	Needs Action	45.32
10	52	09.39	36	67	96	118	83	L	Needs Action	41.19
11	50	09.41	36	84	95	132	83	L	Healthy	46.01
12	55	09.42	36	82	95	134	87	L	Healthy	37.28
13	48	09.45	36	77	96	127	83	L	Healthy	39.91
14	45	09.55	36	65	95	160	94	L	Needs Action	40.40
15	36	09.57	35	68	95	114	78	L	Healthy	50.10
16	31	09.59	37	72	95	132	90	L	Healthy	33.35
17	29	10.57	36	91	95	109	78	L	Healthy	49.11

18	26	10.07	35	80	95	156	109	L	Needs Action	39.20
19	26	10.09	36	91	95	109	78	L	Healthy	40.68
20	42	10.13	36	84	95	165	138	L	Needs Action	44.54
21	44	10.55	36	80	95	156	109	L	Needs Action	46.71
22	26	10.03	37	84	95	165	138	L	Needs Action	35.66
23	27	10.59	36	96	95	120	79	L	Healthy	33.99
24	32	11.02	37	84	96	110	77	L	Healthy	31.50
25	26	11.05	35	75	95	107	76	L	Healthy	33.03
26	49	11.07	36	88	95	131	87	L	Healthy	42.19
27	48	11.09	36	75	95	128	89	L	Healthy	43.54
28	29	11.12	36	72	95	101	74	L	Healthy	49.50
29	52	11.14	36	75	95	163	107	P	Needs Action	37.73
30	26	11.17	36	71	96	113	84	P	Healthy	1.01.21

Table 2 shows data from the examination of wireless medical devices with multi-sensors in 26-55 year old adults. Thirty people were tested for health in the morning and during the day. The data shows 20 adults (66.6%) with "healthy" health status and ten (33.3%) with "need action" health status.

Table 3. Data on Wireless Medical Device Testing Results with Multisensors in the Elderly

No	Age	Hour	Temp (ºc)	Heart Rate(bpm)	SPO2 (%)	Systolic (mmHg)	Diastolic (mmHg)	Gender	Status	Duration (Seconds)
1	66	15.05	35	74	95	133	86	P	Healthy	56.20
2	62	15.07	37	82	95	146	87	L	Healthy	48.20
3	62	15.09	36	65	95	108	63	P	Showing Symptoms	46.65
4	57	15.11	36	70	95	133	86	L	Healthy	51.67
5	61	15.14	37	103	95	153	110	P	Needs Action	56.66
6	60	15.18	36	92	95	136	96	P	Healthy	44.31
7	62	15.20	37	101	95	145	99	P	Healthy	44.12
8	61	15.23	36	89	96	143	101	P	Healthy	37.83
9	53	15.25	37	54	96	115	87	P	Healthy	44.04
10	56	15.29	36	79	96	128	90	P	Healthy	50.30
11	58	15.31	36	84	96	125	89	P	Healthy	40.49
12	62	15.33	36	78	96	147	110	P	Needs Action	40.22
13	63	15.35	36	93	96	122	86	P	Healthy	40.10
14	63	15.37	37	87	95	130	88	P	Healthy	42.19
15	54	15.41	36	85	95	117	85	P	Healthy	43.54

16	60	15.43	37	76	95	131	92	L	Healthy	43.17
17	63	15.45	37	77	95	156	103	L	Needs Action	48.14
18	66	15.48	37	75	95	143	115	P	Needs Action	56.20
19	62	15.51	36	72	95	130	86	L	Healthy	48.20
20	61	15.53	36	57	96	125	88	L	Healthy	42.19
21	62	15.55	36	78	96	119	89	L	Healthy	43.54
22	62	15.57	36	88	96	121	94	P	Healthy	49.50
23	60	15.59	37	58	96	136	105	P	Healthy	42.19
24	56	16.02	37	79	95	117	86	P	Healthy	43.54
25	56	16.05	37	84	95	120	85	P	Healthy	49.50
26	57	16.07	36	81	95	115	88	P	Healthy	37.73
27	57	16.09	36	90	95	100	79	P	Showing Symptoms	1.01.21
28	58	16.12	36	74	95	153	106	P	Needs Action	48.14
29	55	16.14	36	76	96	138	90	P	Healthy	56.20
30	55	16.17	36	81	95	135	86	P	Healthy	48.14

Table 3 shows data from the examination of wireless medical devices with multi-sensors under 56 years old elderly. Thirty people were tested for health in the morning and during the day. The data shows 23 elderly (76.6%) with "healthy" health status, 5 (16.6%) with "need action" health status, and 2 (6.6%) with "symptomic" health status.

Table 4. Time-Based Tool Performance Testing

No	Age	Hour	Temp	Heart Rate (BPM)	SPO2 (%)	Systolic (mmHg)	Diastolic (mmHg)	Gender	Duration (Seconds)
1	21	22.14	36 C	66	94	100	66	P	40.49
2	21	22.20	36 C	72	94	94	64	P	40.22
3	21	22.22	36 C	76	94	94	67	P	40.10
4	21	22.25	37 C	76	94	94	67	P	47.62
5	21	22.28	36 C	76	94	95	66	P	48.14
6	18	22.30	36 C	101	94	104	86	P	51.71
7	18	22.33	36 C	98	94	104	85	P	50.30
8	18	22.35	37 C	96	94	106	82	P	48.22
9	18	22.37	37 C	96	94	106	82	P	51.28
10	18	22.39	37 C	96	94	106	82	P	44.04
11	24	22.41	34 C	101	94	100	94	P	39.57
12	24	22.43	36 C	111	94	100	65	P	35.59
13	24	22.45	37 C	113	95	113	71	P	40.23
14	24	22.47	36 C	92	94	104	72	P	44.12
15	24	22.49	37 C	92	94	104	72	P	37.83
16	24	22.51	38 C	92	94	104	72	P	40.05

17	22	22.53	38 C	68	94	102	69	P	41.80
18	22	22.55	41 C	69	95	103	69	P	46.96
19	22	22.57	37 C	73	95	103	73	P	38.30
20	22	22.59	37 C	74	94	103	69	P	40.30
21	22	23.01	37 C	74	94	103	69	P	44.31
22	18	23.04	35 C	74	94	103	69	P	52.30
23	18	23.06	37 C	94	94	103	90	P	48.93
24	18	23.08	37 C	94	94	104	78	P	59.43
25	18	23.10	37 C	95	94	104	77	P	56.66
26	18	23.16	37 C	87	94	108	84	P	51.67

In data retrieval are several obstacles:

a. V In the MLX90614 temperature sensor: the error can be caused by a procedure error when taking temperature measurements, including the detection distance of the sensor that is not able to be covered by the MLX90614 sensor so that it produces an incorrect reading value.

b. On the Blood Pressure sensor: the position of the hand when testing blood pressure should not be in a tense state, ideally the position when taking measurements on the arm the height of the arm should be parallel to the height of the heart position.

c. The effect of different testing durations on patients is caused by:

d. The level of stability of the hand position, if the arm position is stable, the analysis of the tool against blood pressure testing and temperature sensors will be easier and faster.

Table 5. Accuracy Comparison Testing Tool

No	Age	Original Tool Results					Artificial Tool Results					Difference
		Sys	Dia	Heart Rate (bpm)	Suhu Tubuh (°C)	Kadar Oksigen (%)	Sys	Dia	Heart Rate (bpm)	Suhu Tubuh (°C)	Kadar Oksigen (%)	Angka
1	22	95	71	86	35,1	97	97	67	86	36,77	95	0 - 4
2	21	96	65	89	36,5	94	100	65	95	36,49	95	0 – 6
3	22	100	66	94	36,3	98	96	65	98	36,47	94	0 – 4
4	21	93	67	110	35,5	97	90	63	106	35,19	94	0 – 4
5	22	108	75	83	36.5	94	112	82	85	37	95	1 - 7

Data testing was carried out referring to the reading results of each sensor used to consist of an MLX90614 sensor, MAX30100 sensor, and heart rate and blood pressure sensor. The MLX90614 sensor test received readings in the form of measurement of the patient's body temperature reading values with a reading range from 35 to 37 °C. For blood pressure and heart rate sensor readings, the readings on the instrument compared to standard blood pressure measuring instruments produce relatively accurate readings with differences in values ranging from 0-7 numbers. In oximeter sensor testing, the test is carried out by taking a comparison with a standard oximeter measuring instrument and getting a reading accuracy value with a difference of 1-2 numbers. Based on the results of this test, the accuracy of the tool built is worthy of being applied as a prototype in the medical world, but, to implement it directly, it still requires studies and certifications from authorized institutions to issue medical device eligibility certificates.

4. Conclusion

The electronic devices needed in this series of cigarette smoke control are AF30 smoke sensor, Raspberry Pi, Carbon Fiber, LED Indicator, Exhaust Fan, and Buzzer. This tool was made by assembling electronic devices into a system that can detect cigarette smoke and neutralize it automatically. The sensor has an average normal effectiveness value of 48 ppm and is quite sensitive to cigarette smoke and gases. The sensor takes an average of 2 to 3 seconds to detect smoke or gases in the room. Overall, the tools made can work and function as expected, so they are expected to be used as a means of controlling cigarette smoke in an enclosed space. Raspberry Pi as the main controller is quite efficient because it requires little hardware and the need for a small power supply resource.

References

[1] Hutasoit Masdalia, "Analisis Sistem Informasi Atas Jasa Pelayanan Medical Check Up Pada Rumah Sakit Umum Daerah Dr. Pirngadi Medan," Repos. Univ. HKBP Nommensen, no. Maret, pp. 1–36, 2018.

[2] A. Shiddik, A. Taqwa, and A. S. Handayani, "Multi Sensor Untuk Monitoring Kesehatan," Semin. Nas. Inov. dan Apl. Teknol., pp. 44–49, 2019.

[3] U. Hasanah and Edwita, "Srategi guru dalam meningkatkan healthy lifestyle melalui program literasi hidup sehat," Pendidik. dasar, vol. 10, no. 2, pp. 24–35, 2019.

[4] R. P. Astutik and R. F. Bakti, "SISTEM MONITORING DETAK JANTUNG BERBASIS LoRa," E-Link J. Tek. Elektro dan Inform., vol. 15, no. 1, p. 19, 2020, doi: 10.30587/e-link.v15i1.1606.

[5] P. . Puspitaningayu, A. . Widodo, and E. . Yundra, "Wireless Body Area Networks dan Pengaruhnya dalam Perkembangan Teknologi m-Health," Ina. Indones. J. Electr. Eletronics Eng., vol. 1, no. 1, p. 24, 2018, doi: 10.26740/inajeee.v1n1.p24-30.

[6] P. K. Kusumadani, "Analisis Keamanan Pada Bluetooth Low Energy (Ble): Implementasi Di Wireless Body Area Network (WBAN) Menggunakan Watchdog Sebagai Instrusion Detection System (IDS)," vol. 9, no. 2, pp. 325–330, 2022.

[7] S. Mustaqiim, Ihsan; Taqwa, Ahmad; Handayani, Ade Silvia; Soim, "Perancangan Alat Kesehatan Wireless Body Area Network Multisensor Berbasis Aplikasi Android," Qua Tek., vol. 11, no. 1, pp. 1–21, 2021.

[8] I. Syahdilla and Susilawati, "Jurnal Ilmiah Multi Disiplin Indonesia Pengaruh Latar Belakang Pendidikan Terhadap Kinerja Dan Produktivitas Tenaga Rekam Medis Dan Informasi Kesehatan," Humantech, vol. 1, no. 8, pp. 981–986, 2022.

[9] A. S. Handayani, "Application Of Health Detector (AHD) Dalam Mendeteksi Kesehatan Tubuh Berbasis Android," JATISI (Jurnal Tek. Inform. dan Sist. Informasi), vol. 8, no. 3, pp. 1470–1482, 2021, doi: 10.35957/jatisi.v8i3.1206.

[10] A. S. Handayani et al., "Analysis of Android-based Body Health Monitoring System Results using Fuzzy Mamdani Method," Proc. 5th FIRST T1 T2 2021 Int. Conf. (FIRST-T1-T2 2021), vol. 9, pp. 355–362, 2022, doi: 10.2991/ahe.k.220205.063.

[11] S. Plowerita and J. T. Elektro, "Sistem Monitoring Kesehatan Dalam Penentuan Kondisi Tubuh Dengan Metode Fuzzy Mamdani Irawan Hadi Ade Silvia Handayani Nyayu Latifah Husni," J. Ilm. Tek. Elektro, vol. 8, no. 2, pp. 102–112, 2021.

[12] N. N. H. L. DEWI, "Prototype smart home dengan modul nodemcu esp8266 berbasis internet of things (iot)," 2019, Accessed: Jan. 25, 2022. [Online]. Available: http://repository.unim.ac.id/id/eprint/265.

[13] M. H. Hibatullah, "Pembangunan Aplikasi Sistem Deteksi Kesehatan Sapi Berdasarkan Mata Sapi Berbasis Android - Elibrary Unikom," 2021. https://elibrary.unikom.ac.id/id/eprint/4877/ (accessed Aug. 06, 2022).