Health Card for Teenager Based on Near Field Communication and IoT using Sensor Fusion Method

Noor Cholis Basjaruddin[1,*] Fiter Yogie Saputra[1] Ricky Evan Anugrah Firdaus[1]
Sabar Pramono[1] Fatimah[1] Ediana Sutjiredjeki[1]

[1]*Department of Electrical Engineering, Politeknik Negeri Bandung, Bandung, Indonesia*
[*]*Corresponding author. Email: noorcholis@polban.ac.id*

ABSTRACT
Unhealthy lifestyles affect growth and development in adolescence which causes the Indonesian government to make a Health Card for the Teenager program. This card is used to monitor adolescent development from the parameters such as height and weight. However, the data recording, measurement, and identification for personal data are still conducted manually. Through this research, a device for measuring height, weight, body temperature, heart rate, and Galvanic Skin Response has been realized. This tool can classify nutritional and stress levels status, identify personal data directly with NFC technology, and send data with the IoT. The sensor fusion method classifies the stress level with fuzzy logic and the classification results of stress levels are relaxed, calm, tense, and stressed.

Keywords: *Health Card, NFC, IoT, Sensor Fusion*

1. INTRODUCTION

Development in the health field is an effort in realizing the community, especially for adolescents, to maintain physical health from various diseases that will appear both that take symptoms and without any specific symptoms. In Indonesia, The Health Card or Kartu Menuju Sehat is a card used to monitor adolescent development from the parameters of height and weight.

Previous research has designed the integration of wearables and IoT devices for patient health records [1] [2]. Smart Patient m-Healthcare is also designed to facilitate the monitoring of patients in hospitals with IoT and NFC [3]. There is also a design of data security systems for NFC use in the health care system [4].

Furthermore, an electronic medical record based on NFC and mobile application has been developed that allows doctors to monitor their patients [5] [6]. A device has been developed that works to operate as a medical pre-screening/diagnostic [7]. The tool can perform multiple measurements of health parameters and save its data to databases and smart cards.

In other research, health monitoring tools have been developed that can classify a user's physical condition using some of the user's biosignals that have been measured by utilizing IoT [8]. Then A device has been developed to measure several health parameters and produce health classifications and stress levels with fusion sensors [9]. A tool has been developed to measure multiple health parameters utilizing NFC and IoT. This tool can produce nutritional and infant health classifications with sensor fusion [10].

2. BACKGROUND

Health Card for Teenagers is an effort in monitoring adolescent development from the measured parameters such as height and weight. Poor growth due to infection or malnutrition, or other reasons, both in individuals and in population groups, needs to be detected for improvement. However, the measurement process often occurs manually using a meter. If the data collected comes from hundreds of people, this of course resulted in the data collected amounting to thousands of data. It will be very difficult and require a lot of time to process. Therefore, this study will develop a tool design model that provides convenience in terms of technology for measuring nutritional status and stress level in teenagers based on NFC and IoT using sensor fusion method

3. RESEARCH METHODS

3.1. System Design

The system starts with the smartphone application that sends data of the family registration number, date of

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birth, and gender to the NFC reader module. Next, the sensor reads height, weight, and body temperature. Then they are sent into the Raspberry Pi microcontroller to store the measurement data. Raspberry Pi sends a code to Arduino Nano using serial data communication, then it takes the readings from the heart rate and skin conductance sensor. The data obtained is transferred back to the Rasberry Pi to be processed. The nutritional status, stress levels, and the measured data will be displayed on the LCD and sent to the cloud database. The cloud database will send data to the smartphone application via the internet as presented in Figure 1.

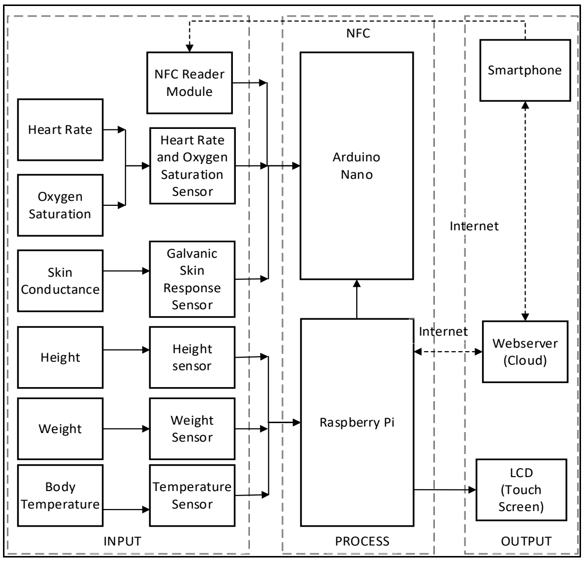

Figure 1 Nutritional and stress level monitoring system

3.2. Sensor fusion

Fusion sensors are used to combine sensory data so that the information generated is in some ways better than what might have been possible if the sources were processed separately. The classification of the fusion sensor to determine the stress level in Figure 2 is the result of the final decision. The sensor data processing algorithm uses a fuzzy logic algorithm with the method used by Mamdani in making the final decision. The parameter data used as input for stress levels are body temperature, heart rate, skin conductance, or GSR with the results of the stress level classification resulting in four categories, namely relaxed, calm, anxiety and stressed as presented in Table 1.

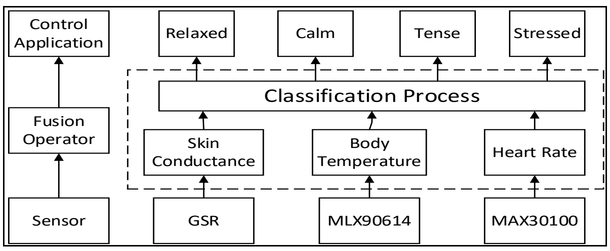

Figure 2 Sensor fusion for nutritional status

The fuzzy membership function is as follows:

1. Membership Function GSR

Membership function GSR has 4 membership functions namely low, middle, high, and extreme as seen in Figure 3.

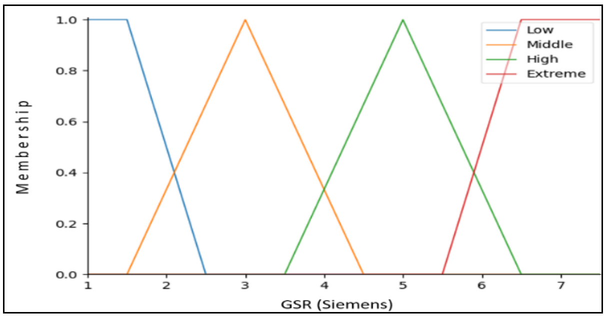

Figure 3 Membership Function GSR

2. Membership Function Heart Rate (HR)

Membership function heart rate has 4 membership functions namely low, middle, high, and extreme as seen in Figure 4.

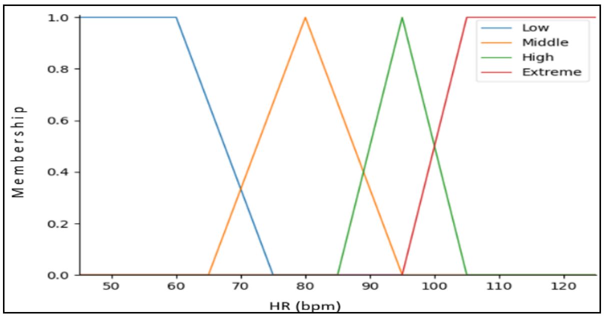

Figure 4 Membership Function Heart Rate (HR)

3. Membership Function Temperature (T)

Membership function temperature has 4 membership functions namely low, middle, high, and extreme as seen in Figure 5.

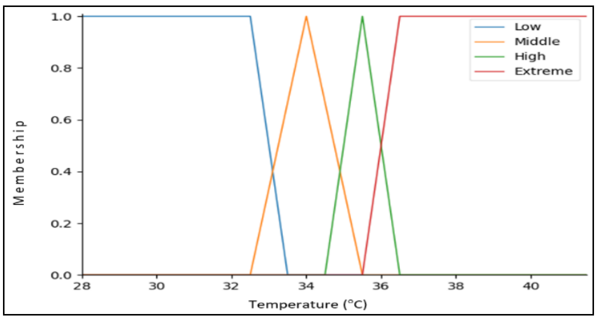

Figure 5 Membership Function Temperature (T)

Table 1. Measurement accuracy of sensor modules

Classification	Parameter		
	GSR (Siemens)	HR (bpm)	T (°C)
Relaxed	< 2	60 - 70	36 - 37
Calm	2 - 4	70 - 90	35 - 36
Tense	4 - 6	90 - 100	33 - 35
Stressed	> 6	> 100	< 33

4. Membership Function stressed level

Membership function stressed level has 4 membership functions namely relaxed, calm, tense, and stressed see in Figure 6.

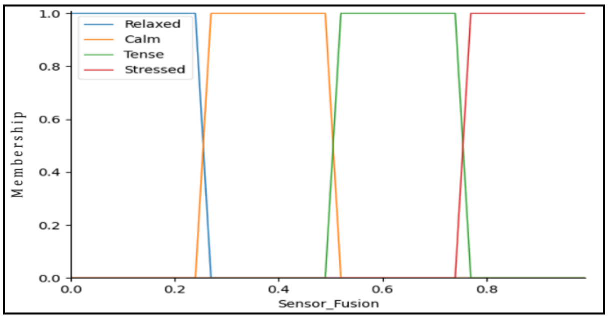

Figure 6 Membership Function stressed level

The overall fuzzy rules can be seen in Table 2. Fuzzy rules contain GSR, heart rate, and temperature input each of which consists of low, middle, high, and extreme. The resulting decisions are relaxed, calm, tense, and stressed.

Fuzzy output data is still a value, while the required result is a decision. Therefore, the value of the fuzzy output needs to be reclassified to determine the final result as follows:

Relaxed = $\{0 \leq X \leq 0.258\}$ Calm = $\{0.258 < X \leq 0.5051\}$
Stressed = $\{0.744 < X \leq 1\}$ Tense = $\{0.5051 < X \leq 0.744\}$

Table 2. Fuzzy rules for GSR, heart rate, and temperature

GSR	T \ HR	Low	Middle	High	Extreme
Low	Low	Calm	Relaxed	Relaxed	Relaxed
	Middle	Relaxed	Calm	Calm	Calm
	High	Calm	Tense	Tense	Tense
	Extreme	Tense	Tense	Tense	Tense
Middle	Low	Calm	Calm	Calm	Relaxed
	Middle	Tense	Calm	Calm	Calm
	High	Tense	Tense	Tense	Calm
	Extreme	Tense	Tense	Calm	Calm
High	Low	Tense	Calm	Calm	Calm
	Middle	Tense	Tense	Calm	Calm
	High	Tense	Tense	Tense	Calm
	Extreme	Stressed	Tense	Stressed	Tense
Extreme	Low	Tense	Calm	Calm	Calm
	Middle	Stressed	Tense	Tense	Tense
	High	Tense	Tense	Tense	Stressed
	Extreme	Stressed	Stressed	Stressed	Stressed

3.3. Nutritional status

Body Mass Index or BMI is a parameter established by the World Health Organization (WHO) as a comparison of body weight to the square of height. BMI is determined by measuring weight and height separately then the weight and height values are divided to get the BMI value in kg/m2. Z-Score is sample data in a data set to determine the nutritional status of body mass index for age, as seen in Table 3.

Table 3. The classification results of the stress level

Index	Nutritional Status Category	Threshold Z-Score
Children aged 5-18 years	Malnutrition	< -3 SD
	Thinness	-3 SD to -2 SD
	Normal	-2 SD to +1 SD
	Fat	+1 SD to +2 SD
	Obesity	> +2 SD

3.4. Mobile Application Design

In the mobile application, users can monitor nutritional status and stress levels from the measurement results. This mobile application was created with the MIT APPinventor. The mobile application flow diagram design can be seen in Figure 7.

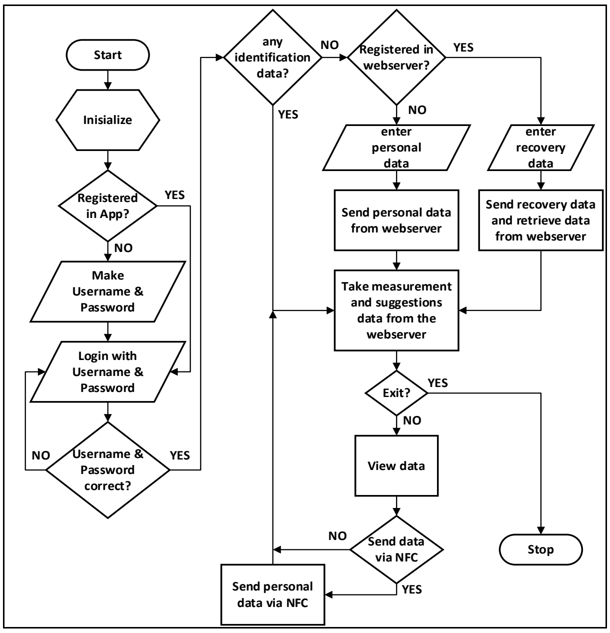

Figure 7 Mobile application flowchart

3.5. Web-Based Application Design

Paramedics or doctors can access health data stored in the database by logging into the webserver. In addition, They can provide health advice to users through this webserver. The webserver flow diagram can be seen in Figure 8.

3.6. Result

3.6.1. Sensor Test

In this tool, testing is done on every sensor that is used. The weight sensor was tested by measuring several objects of different weights and compared to standard digital scales. The test of weight sensors obtained an accuracy of 98.59%. The height sensor was tested by measuring the distance from the altered object several times its distance to the sensor and compared to a rolling meter. The test of the height sensor obtained an accuracy of 98.93%. The temperature sensor was tested by measuring objects whose temperatures are changed several times and compared to standard body thermometers. The temperature sensor test obtained an accuracy of 98.59%. The heart rate sensor was tested by measuring a person's heart rate several times and compared to a standard heart rate sensor. The test of the heart rate sensor obtained an accuracy of 94.39%. The GSR sensor was tested by measuring the resistance on the resistor and compared to a digital multimeter. From testing, the GSR sensor obtained an accuracy of 98.81%.

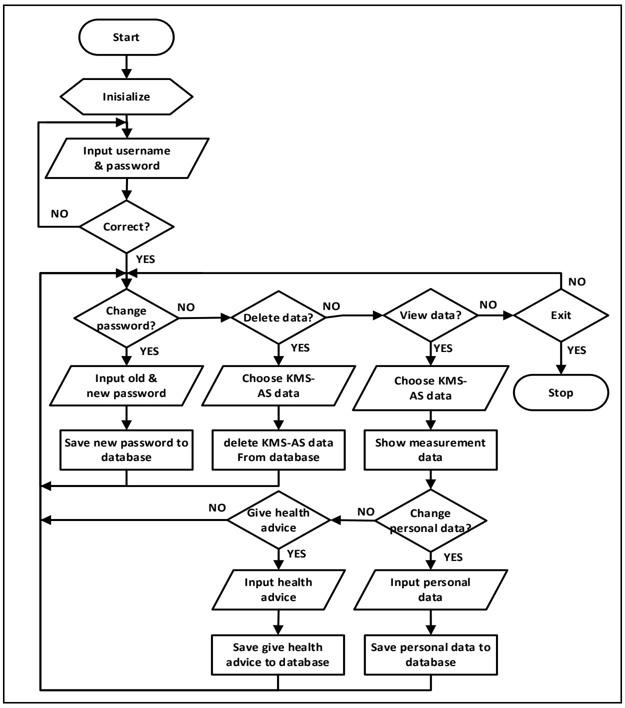

Figure 8 Web-based application flowchart

3.6.2. Sensor Fusion Method Test

The inputs required to determine the level of stress are temperature, GSR, and heart rate. The classification results of the levels are relaxed, calm, tense, and stressed. Test data was performed using 10 samples as presented in Table 4. Inputs used to determine nutritional status are age, gender, weight, and height. The results of the classification of nutritional status are malnutrition, thinness, normal, fat, and obesity. Testing was carried out using 10 samples as seen in Table 5.

3.6.3. NFC and IoT Communication Test

Data sent via NFC is ID, gender, and date of birth. Data transmission is done by tapping NFC to a smartphone. The data received by the tool can be seen in Figure 9. Parameter and classification data are then transmitted by IoT to the webserver and can be accessed by a smartphone on the mobile application, as seen in Figure 10-11.

Table 4. The classification results of the stress level

No	Temperature (°C)	GSR	Heart Rate (bpm)	Fuzzy Value	Result
1	36.2	1.74	70	0.2575	Relaxed
2	36.7	3.26	74	0.3558	Calm
3	35.6	2.47	76	0.3800	Calm
4	37.9	3.92	90	0.3800	Calm
5	35.6	2.67	85	0.3800	Calm
6	36,0	2.80	81	0.3800	Calm
7	41.1	2.26	84	0.3800	Calm
8	34.6	2.97	88	0.4781	Calm
9	35.1	4.12	101	0.6546	Tense
10	34.1	5.94	114	0.7529	Stressed

Table 5. The results of the classification of nutritional status

No	Age (months)	Gender	Weight (kg)	height (cm)	Z-Score	Result
1	162	Female	34.1	168.4	-3.12	Malnutrition
2	164	Male	35.7	158.6	-2.37	Thinness
3	197	Female	50.2	162.7	-0.74	Normal
4	180	Female	49.6	161.2	-0.46	Normal
5	189	Male	51.8	163.5	-0.42	Normal
6	173	Male	47.2	159.2	-0.34	Normal
7	183	Male	53.3	161.2	0.18	Normal
8	211	Male	58.1	153.3	1.01	Fat
9	166	Male	57.4	157.1	1.61	Fat
10	201	Male	79.4	169.5	2.14	Obesity

Figure 9 NFC communication test

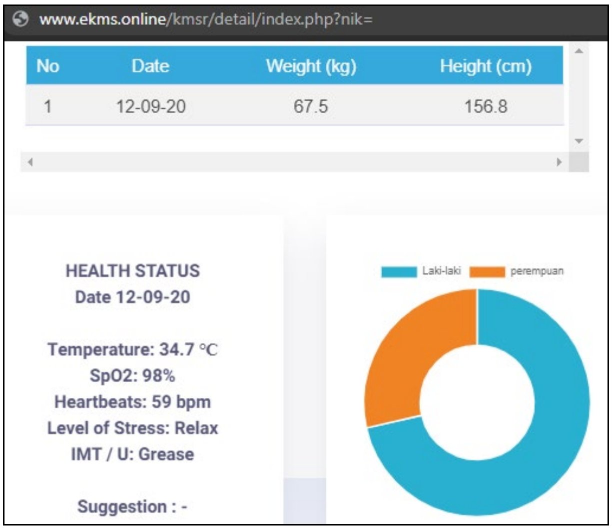

Figure 10 Data received in webserver

Figure 11 Data accessed Mobile application

4. CONCLUSION

The device for measuring stress level and nutritional status has been designed successfully and is following the expected function. The measurement data obtained, such as weight, height, temperature, heart rate, and GSR have been successfully stored in the smartphone application database and webserver.

NFC communication runs well when the smartphone application sends data to the device. The sensors that have been used in the device have a very high degree of precision and accuracy, as well as a very small relative error.

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