Fuzzy logic method-based stress detector with blood pressure and body temperature parameters

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ABSTRACT

In this study, using the fuzzy logic method, a stress detection tool was created with body temperature and blood pressure parameters as indicators to determine a person's stress level. This tool uses the LM35DZ sensor to detect body temperature, the MPX5100GP sensor to read blood pressure values, and Arduino Uno as a data processor from sensor readings which are then calculated using the fuzzy logic method as a stress level decision-maker. The resulting output measures blood pressure, body temperature, and the stress level experienced by a person, which will be displayed on the liquid crystal display. Based on the results of testing the body temperature parameter, the highest error generated was 1.17%, and for the blood pressure parameter, the highest error was 2.5% for systole and 0.93% for diastole. Furthermore, testing the stress level displayed on the tool is compared to the depression, anxiety, and stress scales 42 (DASS 42), a psychological stress measuring instrument. From the results of testing the tool with the questionnaire, the average conformity level is 74%.

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1. INTRODUCTION

Stress is pressure or something that feels pressing in a person caused by an imbalance between expectations and reality desired by the individual [1]. According to McGrath in Weinberg and Gould, stress is defined as “a substantial imbalance between demand (physical and/or psychological) and response capability, under conditions where failure to meet that demand has important consequences” [2]. That is, stress will arise in individuals when there is an imbalance or individual failure to meet their physical and spiritual needs [3]. Physical symptoms that are caused when individuals experience stress is characterized by: high blood pressure, abnormal body temperature, heart problems, tension in the muscles, cold palms or feet, dizziness, indigestion, stomachache, and insomnia for women experiencing menstrual disorders [4].

High blood pressure with systolic values >130 mmHg, diastolic >110 mmHg, and a cold body temperature of less than 33 °C can indicate that the person is experiencing stress [5]. Table 1 shows the level of emotion state with blood pressure and body temperature values for each state [6]. Prolonged stress can be fatal to health because it may cause various diseases and reduce body immunity [7]. To avoid the impact caused by stress, we need a tool to detect stress levels in individuals by measuring blood pressure and body temperature [8].

Table 1. Blood pressure and body temperature value of stress level [6]

Variable	Parameter	
	Blood Pressure (mmHg)	Body Temperature (°C)
Relax	100/70–110/75	36–37
Calm	110/75–120/85	35–36
Anxiety	120/90–130/110	33–35
Stress	Systole >130, Diastole >110	<33

Previous research [9] created a stress level detection tool based on body temperature, skin moisture, blood pressure, and heart rate. This tool used the following sensors: The MPX5050dp detects blood pressure and heart rate, the LM35dz sensor detects body temperature, and the GSR sensor measures the skin resistance of two fingers. The test obtained measurement results with an average error of 3.5% for galvanic skin response (GSR), 1.4% for temperature, 11.76% for heart rate, and 9.87% for blood pressure. From the measurement results, it can be concluded that the tool is able to provide information on human stress conditions, but when measuring blood pressure and heart rate using the MPX5050dp sensor, it has a very high percentage of error, and there is no comparison (psychological instrument) to compare the result.

Subsequent research was conducted by Calero [10], which made a stress detection device based on the Atmega8535 microcontroller using the GSR sensor to measure the skin resistance of two fingers and the MPX5050DP to detect blood pressure. The results of blood pressure measurements have an accuracy rate of 96.43% for high blood pressure (systole) and 97.12% for low blood pressure (diastolic), and the GSR sensor functions properly. The lack of tools has no validation to determine stress levels, so the results are inaccurate because the stress level decision-making is calculated manually.

Based on the problems above, in this research the author will design a stress detection tool using the fuzzy logic method. The parameters used in this research are blood pressure and body temperature which can be used to measure individual stress levels [11]. For measurements, the MPX5100GP sensor is used to measure blood pressure and the LM35DZ sensor is used to measure body temperature [12], [13]. This tool, using the fuzzy logic method, can be operated automatically and can display four conditions, namely stress (S), anxiety (A), calm (C), and relax (R) [14], and the result will be compared with DASS 42 [15] as a psychological instrument to detect stress.

The fuzzy logic method is a method that can process variables that are fuzzy or cannot be described with certainty [16]. The advantages of the fuzzy logic method are that it is easy to understand because it uses the basis of set theory, is very flexible, meaning that it is able to adapt to changes and uncertainties that accompany problems, has tolerance for inaccurate data, is able to model very complex nonlinear functions [17], can build and apply the experiences of experts directly without having to go through a training process which is often known as the fuzzy expert system, can work with conventional control techniques [18]–[20]. Fuzzy logic is also based on everyday language, so it is easy to understand [21].

2. METHOD

2.1. Fuzzy logic block diagram

Figure 1 shows that blood pressure and body temperature are inputs from the fuzzy system, fuzzification functions to convert blood pressure and body temperature values into membership functions. Blood pressure is divided into 4 membership functions: low, normal, slightly high, and high, while body temperature is divided into 4 functions: cold, slightly cold, slightly hot, and hot. Reasoning is an implication process in reasoning input values for determining output values in decision-making [22]. Consequently, the applied rule is through minimum reasoning. The basic rules in this fuzzy system are in the form of an $IF\text{-}Then$ relation consisting of 16 rules [23]. Defuzzification changes fuzzy output values into firm output values, which are relaxed, calm, anxious, and stressed.

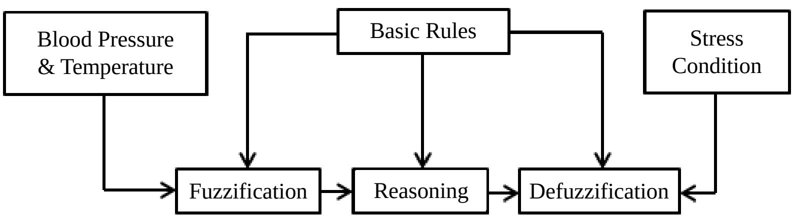

Figure 1. Fuzzy logic block diagram [24]

2.2. Fuzzy logic system

The fuzzy logic system in this tool uses several inputs and one output [25]. The input used is blood pressure and body temperature, while the output is stress level. Therefore, it is necessary to design a membership function for each input (blood pressure and body temperature), as well as a membership function for the output (stress level).

2.2.1. Membership function of blood pressure

The membership function of blood pressure can be seen in Figure 2. Blood pressure is divided into four levels: low blood pressure, normal blood pressure, slightly high blood pressure, and high blood pressure, with a range of less than 100 mmHg to more than 120 mmHg. The fuzzy input to determine the blood pressure points uses triangular curves. The mathematical blood pressure membership function model [26] is annotated with (1)-(4).

- Low blood pressure, <100 mmHg
- Normal blood pressure, 100-120 mmHg
- Slightly high blood pressure, 110-130 mmHg
- High blood pressure, >120 mmHg

$$\mu\, Low\ blood\ pressure = \begin{cases} \frac{110-x}{110-100} & ; 100 \le x \le 110 \\ 0 & ; x \ge 110 \\ 1 & ; \le 100 \end{cases} \quad (1)$$

$$\mu\, Normal = \begin{cases} 0 & ; x \le 100\ or\ x \ge 120 \\ \frac{x-100}{110-100} & ; 100 \le x \le 110 \\ \frac{120-x}{120-110} & ; 110 \le x \le 120 \end{cases} \quad (2)$$

$$\mu\, Slightlyhigh = \begin{cases} 0 & ; x \le 110\ or\ x \ge 130 \\ \frac{x-110}{120-110} & ; 110 \le x \le 120 \\ \frac{130-x}{130-120} & ; 120 \le x \le 130 \end{cases} \quad (3)$$

$$\mu\, High = \begin{cases} 0 & ; x \le 120 \\ \frac{x-120}{130-120} & ; 120 \le x \le 130 \\ 1 & ; \ge 130 \end{cases} \quad (4)$$

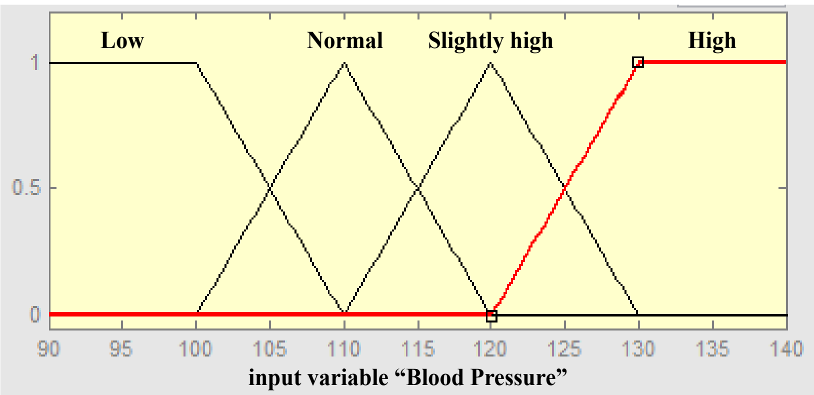

Figure 2. Blood pressure membership function

2.2.2. Membership function of body temperature

The membership function of body temperature is divided into four levels: cool body temperature, slightly cold, slightly hot, and hot body temperature, with a range of less than 34 °C to more than 35 °C. The mathematical model of body temperature membership function [27] is annotated with (5)-(8). Graphic of body temperature membership function can be seen in Figure 3.

– Cool body temperature, <34 °C
– Slightly cold body temperature, 33 °C to 35 °C
– Slightly hot body temperature, 34 °C to 36 °C
– Hot body temperature, >35 °C

$$\mu\, Cold = \begin{cases} \frac{34-x}{34-33} & ; 33 \leq x \leq 34 \\ 0 & ; x \geq 34 \\ 1 & ; \leq 33 \end{cases} \quad (5)$$

$$\mu\, Slightly\ cold = \begin{cases} 0 & ; x \leq 33\ or\ x \geq 35 \\ \frac{x-33}{34-33} & ; 33 \leq x \leq 34 \\ \frac{35-x}{35-34} & ; 34 \leq x \leq 35 \end{cases} \quad (6)$$

$$\mu\, Slightly\ hot = \begin{cases} 0 & ; x \leq 34\ or\ x \geq 36 \\ \frac{x-34}{35-34} & ; 34 \leq x \leq 35 \\ \frac{36-x}{36-35} & ; 35 \leq x \leq 36 \end{cases} \quad (7)$$

$$\mu\, Hot = \begin{cases} 0 & ; x \leq 35 \\ \frac{x-35}{36-35} & ; 35 \leq x \leq 36 \\ 1 & ; \leq 36 \end{cases} \quad (8)$$

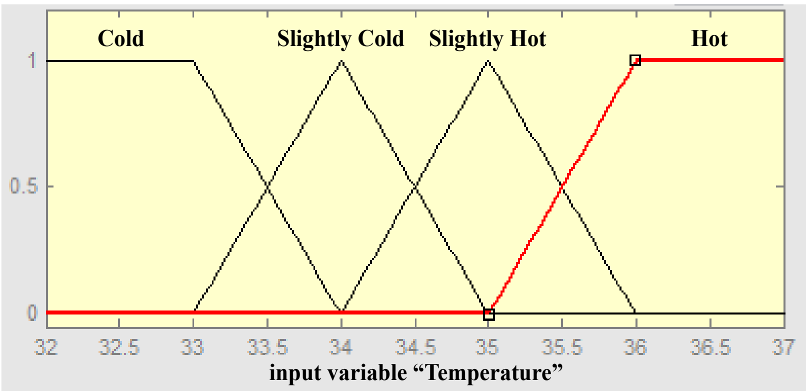

Figure 3. Body temperature membership function

2.2.3. Stress level (output) membership function

The stress level is an output of this research. The membership function of output is divided into four levels: relax, calm, anxiety, and stress. The relax condition is in the range of 0-25, the calm level has a value of 25-50, the anxiety level ranges from 50-75, and the stress condition is 75-100. Diagram of stress level membership function can be seen in Figure 4, while the mathematical model is provided at the (9)-(12) [28].

a. Relax (R) (0–25)
b. Calm (C) (25–50)
c. Anxiety (A) (50–75)
d. Stress (S) (75–100)

$$\mu\, R = \begin{cases} 0 & ; x \leq 0\ or\ x \geq 25 \\ \frac{x-0}{12{,}5-0} & ; 0 \leq x \leq 25 \\ \frac{12.5-x}{25-12.5} & ; 12.5 \leq x \leq 25 \end{cases} \quad (9)$$

$$\mu R = \begin{cases} 0 & ; x \leq 0 \text{ or } x \geq 25 \\ \frac{x-0}{12.5-0} & ; 0 \leq x \leq 25 \\ \frac{12.5-x}{25-12.5} & ; 12.5 \leq x \leq 25 \end{cases} \quad (10)$$

$$\mu C = \begin{cases} 0 & ; x \leq 50 \text{ or } x \geq 75 \\ \frac{x-50}{62.5-50} & ; 50 \leq x \leq 62.5 \\ \frac{62.5-x}{75-62.5} & ; 62.5 \leq x \leq 75 \end{cases} \quad (11)$$

$$\mu S = \begin{cases} 0 & ; x \leq 75 \text{ or } x \geq 100 \\ \frac{x-75}{82.5-75} & ; 75 \leq x \leq 82.5 \\ \frac{82.5-x}{100-82.5} & ; 82.5 \leq x \leq 100 \end{cases} \quad (12)$$

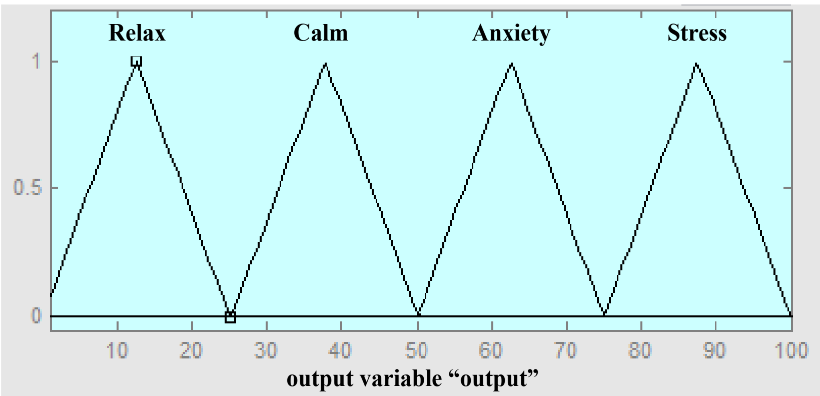

Figure 4. Stress level membership function

In the stress level fuzzy system, there are 2 input data (blood pressure and body temperature), then a rule is created to produce the desired output. There are 2^4 (16) rules [29] that will produce the following outputs:

- If blood pressure is low and temperature is hot, the output is relax.
- If the blood pressure is low and the temperature is slightly hot, the output is relax.
- If the blood pressure is low and the temperature is slightly cool, the output is calm.
- If blood pressure is low and the temperature is cool, the output is calm.
- If blood pressure is normal and temperature is hot, the output is relax.
- If the blood pressure is normal and the temperature is slightly hot, the output is calm.
- If the blood pressure is normal and the temperature is slightly cool, the output is anxiety.
- If the blood pressure is normal and the temperature is cool, the output is anxiety.
- If the blood pressure is slightly high and the temperature is hot, the output is calm.
- If blood pressure is slightly high and temperature is slightly hot, the output is anxiety.
- If blood pressure is slightly high and the temperature is slightly cool, the output is anxiety.
- If the blood pressure is slightly high and the temperature is cool, the output is stress.
- If blood pressure is high and temperature is hot, the output is calm.
- If the blood pressure is high and the temperature is slightly hot, the output is anxiety.
- If the blood pressure is high and the temperature is slightly cool, the output is stress.
- If blood pressure is high and the temperature is cold, the output is stressed.

3. RESULTS AND DISCUSSION

3.1. Blood pressure test result

Data retrieval on blood pressure parameters was done by comparing the measurement results between tools made with a digital tensimeter calibration tool, a vital sign simulator. The data collection process is carried out with 15 measurements for each measurement point set on the vital sign's simulator. This test was carried out to determine the feasibility of the tool made.

Based on the results of blood pressure measurements at 3 measurement points on Table 2, the pressure was 120/80 mmHg with an average measured on the tool made of 119.9/80.7 mmHg while the average on vital signs simulators was 120/80 mmHg, then the value the error obtained is 0.058/0.83%. The average pressure of 150/100 mmHg measured on the device is 148.33/99.8 mmHg, while the average on vital signs stimulators is 150/100 mmHg. The error value obtained was 1.11/0.2%. At a pressure of 200/150 mmHg, the average measured on the device is 205/151.4 mmHg, while the average on vital sign stimulators is 200/150 mmHg, the error value was 2.5/0.93%.

Based on the results of blood pressure measurements at 3 measurement points, pressure 120/80, 150/100 mmHg, and 200/150 mmHg, the highest error values obtained were 2.5% for systolic pressure and 0.93% for diastolic pressure. Based on the results of the error obtained, it is quite good because it has a small enough difference in value with the comparison tool to show that the device is working properly.

Table 2. Blood pressure test results

No.	Blood pressure point tests (systole/diastole)	Vital sign simulator average	Tool average	Error
1	120/80 mmHg	120/80 mmHg	119.93/80.7 mmHg	0.058/0.83%
2	150/100 mmHg	150/100 mmHg	148.33/99.8 mmHg	1.11/0.2%
3	200/150 mmHg	200/150 mmHg	205/151.4 mmHg	2.5/0.93%

3.2. Temperature test result

Data collection for temperature parameters was obtained by comparing the tools that the author made with a digital thermometer. The data collection process was carried out 10 times with measurements on the respondents. The following results are from a comparison of the tool data that the author made with a digital thermometer.

Based on the testing of the temperature parameter on Table 3, for respondent 1, the temperature was 35.29 °C when measured using a digital thermometer, while the average for the tools was 35.16 °C, and the error was 0.36%. In respondent 2, the temperature obtained from a digital thermometer was 35.9 °C, it was 35.8 °C from the tool with an error of 0.33%. Respondent 3 obtained an average of 35ºC using a digital thermometer and 34.9 °C on the tool with an error of 0.28%. Respondent 4 temperature measurements using a digital thermometer resulted in 35.8 °C, and using the tool resulted in 35.7 °C with an error of 0.27%. For respondent 5, the average temperature measurement using a digital thermometer was 36.3 °C, while using the tool was 36.2 °C, with an error value of 0.27%. Based on the results of the tests, the highest error obtained was 0.367% (respondent 1). From these results, the temperature parameter using the LM35DZ sensor works very well and is still within the tolerance range (±1%) [30].

Table 3. Temperature test results

No.	Blood pressure point tests (systole/diastole)	Vital sign simulator average	Tool average	Error
1	Respondent 1	35.29 °C	35.16 °C	0.36%
2	Respondent 2	35.94 °C	35.82 °C	0.33%
3	Respondent 3	35 °C	34.9 °C	0.28%
4	Respondent 4	35.8 °C	35.7 °C	0.27%
5	Respondent 5	36.3 °C	36.2 °C	0.27%

3.3. Stress level testing

In Table 4, the test was carried out by testing 7 respondents with 10 measurements for each respondent. In the first respondent, the results of the decision were obtained; "Relax (R)" 7 times with the body temperature value of 35.7 °C to 36.2 °C, and blood pressure value of 111-116 mmHg, and "Calm (C)" 6 times with blood pressure value of 107 mmHg-119 mmHg and body temperature of 35.4 °C to 35.8 °C. The second respondent has 2 conditions, "Relax (R)" 9 times with a measured value of about 35.4 °C to 36.2 °C for body temperature and 103-112 mmHg for systolic blood pressure and "Calm (C)" once with a body temperature of 35.3 °C and 114 mmHg for blood pressure. The third respondent had 2 conditions: "Relax (R)" 8 times with a measured value of around 35.3 °C to 36.3 °C for body temperature and 100-132 mmHg for systolic blood pressure. The "Calm (C)" condition happened 2 times with measurement results for body temperature of 35.1 °C to 35.4 °C and blood pressure of 111 to 117 mmHg for systolic blood pressure. The fourth respondent has 2 conditions: "Relax (R)" 7 times, with measurement results obtained around 36.3 °C to 36.9 °C for body temperature and 130 mmHg to 138 mmHg for systolic blood pressure.

The “Calm (C)” condition occurred 3 times, with the value of the measurement results obtained around 35.2 °C to 35.8 °C for body temperature and 134 to 138 mmHg for systolic blood pressure. The fifth respondent has 3 conditions: “Relax (R)” 5 times with a measurement result of around 35.7 °C to 36.1 °C for body temperature and 106-116 mmHg for systolic blood pressure, conditions measured around 36.3 °C for body temperature and 132 mmHg for blood pressure systole. “Calm (C)” condition occurred 4 times with measurement results of 35.2 °C to 35.9 °C for body temperature and 123 to 126 mmHg for systolic blood pressure, and “Anxiety (A)” condition happened 1 time with measurement results obtained 34.7 °C for body temperature and 132 mmHg for systolic blood pressure. The sixth respondent has a condition of “Relax (R)” with a measured value of around 35.9 °C for body temperature and 97 mmHg for systolic blood pressure. The last respondent had the condition: “Relax (R)” 8 times with a measured value of around 36 °C to 36.7 °C for body temperature and 107 to 119 mmHg for systolic blood pressure, “Calm (T)” condition 2 times with a measured value of around 36.8 °C for body temperature and 119 to 123 mmHg for systolic blood pressure.

Table 4. Results of measurement of stress conditions

No.	Respondents						
	1	2	3	4	5	6	7
1	T=35.4 BP=107 C	T=35.3 BP=114 C	T=35.1 BP=111 C	T=35.6 BP=137 C	T=34.7 BP=132 A	T=35.2 BP=100 R	T=36 BP=116 R
2	T=35.6 BP=110 C	T=35.4 BP=107 R	T=35.3 BP=100 R	T=35.8 BP=138 C	T=35.2 BP=123 C	T=35.4 BP=96 R	T=36.2 BP=119 R
3	T=35.5 BP=119 C	T=35.6 BP=111 R	T=35.4 BP=117 C	T=36.3 BP=132 R	T=35.5 BP=126 C	T=35.5 BP=98 R	T=36.3 BP=108 R
4	T=35.5 BP=117 C	T=35.7 BP=112 R	T=36.3 BP=132 R	T=36.7 BP=138 R	T=35.7 BP=111 R	T=35.6 BP=101 R	T=36.5 BP=118 R
5	T=35.7 BP=111 R	T=35.9 BP=103 R	T=35.7 BP=106 R	T=36.8 BP=131 R	T=35.8 BP=125 C	T=35.7 BP=96 R	T=36.5 BP=112 R
6	T=35.8 BP=115 C	T=36 BP=104 R	T=35.9 BP=105 R	T=36.8 BP=135 R	T=35.9 BP=116 C	T=35.8 BP=92 R	T=36.6 BP=107 R
7	T=35.8 BP=115 C	T=36 BP=104 R	T=35.9 BP=105 R	T=36.9 BP=135 R	T=36 BP=116 R	T=35.9 BP=92 R	T=36.7 BP=107 R
8	T=36.2 BP=116 R	T=36.1 BP=108 R	T=35.9 BP=100 R	T=36.9 BP=136 R	T=36 BP=112 R	T=35.9 BP=97 R	T=36.7 BP=116 R
9	T=36.2 BP=115 R	T=36.2 BP=104 R	T=36 BP=117 R	T=36.9 BP=137 R	T=36 BP=115 R	T=36 BP=104 R	T=36.8 BP=119 C
10	T=36.1 BP=113 R	T=36.2 BP=106 R	T=36 BP=111 R	T=35.2 BP=134 C	T=36.1 BP=106 R	T=36 BP=106 R	T=36.8 BP=123 C
Value	R= 4 C=6	C=1 R=9	C=2 R= 8	C=3 R=7	A=1 C=4 R=5	R=10	C=2 R=8

3.4. DASS 42 test

DASS 42 is a questionnaire with 42 questions, consisting of 3 emotional scales: depression, anxiety, and stress with levels as shown in Table 5; normal, mild, moderate, severe, and very severe [31]. The DASS 42 scale can be classified into 3 [32], which are the depression scale (questions number 3, 5, 10, 13, 16, 17, 21, 24, 26, 31, 34, 37, 38, 42), the anxiety scale (questions number 2, 4, 7, 9, 15, 19, 20, 23, 25, 28, 30, 36, 40, 41.3), and the stress scale (questions number 1, 6, 8, 11, 12, 14, 18, 22, 27, 29, 32, 33, 35, 39).

Table 5. Categorization of stress level (DASS 42) [33]

Level	Depression	Anxiety	Stress
Normal	0 – 9	0 – 7	0 – 14
Mild	10 – 13	8 – 9	15 – 18
Moderate	14 – 20	10 – 14	19 – 25
Severe	21 – 27	15 – 19	26 – 33
Very Severe	>28	>20	>34

From the results of testing the DASS 42 questionnaire that was carried out, it can be seen in Table 6 that the first respondent has a normal depressive condition because the results obtained in filling out the DASS 42 questionnaire only produce a value of 2, normal anxiety because it produces a value of 3, and normal stress because it produces a value of 6. Meanwhile, the second respondent has a normal depressive condition because it produces a score of 9, severe anxiety because it produces a high score, namely 16, and normal stress because it produces a value of 0. Then, the third respondent has a normal depressed condition because it produces a value of 1, normal anxiety because it produces a value of 0, and normal stress because it produces a value of 0. The fourth respondent is normal for depression because it produces a value of 6, normal anxiety because it produces a value of 11. The fifth respondent is normal depression because it produces a value of 6, normal anxiety because it produces a value of 6, and normal stress because it produces a value of 10. Furthermore, the sixth respondent is normal depression because it produces a value of 6, normal anxiety because it produces a value of 0, and normal stress because it produces a value of 3. The last respondent has a condition of normal depression because it produces a value of 4, moderate anxiety because produces a high enough value of 10, and mild stress because it produces a value of 15.

Table 6. DASS 42 test results

No	Respondent (s)	Depression	Anxiety	Stress	Conditions
1	Respondent 1	2	3	6	Normal depression, Normal anxiety, Normal stress
2	Respondent 2	9	16	0	Normal depression, Normal anxiety, Normal stress
3	Respondent 3	1	0	0	Normal depression, Normal anxiety, Normal stress
4	Respondent 4	6	7	11	Normal depression, Normal anxiety, Normal stress
5	Respondent 5	6	6	10	Normal depression, Normal anxiety, Normal stress
6	Respondent 6	6	0	3	Normal depression, Normal anxiety, Normal stress
7	Respondent 7	4	10	15	Normal depression, Normal anxiety, Normal stress

3.5. Comparison of tool testing and DASS 42 tests

Comparison of tool testing is carried out in order to get accurate results in measuring psychological stress. The comparison is made by testing the detection tool and comparing the results with the DASS 42 test. The following conversion of DASS 42 to a tool module can be seen in Table 7.

Table 7. Conversion of DASS 42 test to tool [15]

DASS 42	Tool
Depression, Anxiety, Stress; Normal dan Mild	Relax (R)
Depression, Anxiety, Stress; Moderate	Calm (C)
Depression, Anxiety, Stress; Severe	Anxiety (A)
Depression, Anxiety, Stress; Very Severe	Stress (S)

In can be seen from Table 7 that DASS 42 test is divided into 3 scales namely depression, anxiety and stress. Each scale consists of 4 conditions, namely normal/mild, moderate, severe, and very severe [34]. Of the 3 scales, if they have at least 2 conditions that are the same as the tool, then they can be used as a benchmark for the most dominating suitability level [5]. If the DASS 42 test is not the same as the tool, then there is no compatibility. The following results of the comparison of the DASS 42 test can be seen in Table 8.

From the results of the comparison of the DASS 42 test with the designed stress detection tool, it can be seen in Table 8 that the DASS 42 test for first respondent had the results: normal depression, normal anxiety, and normal stress while the results for the tool are 60% calm and 40% relaxed, because of the 3 scales it has 3 under normal conditions, it can be converted into relaxed (R) with a suitability level of 40%. Whereas in the second respondent the results of the DASS 42 test had normal conditions of depression, severe anxiety, and normal stress. Of the 3 scales, there are 2 normal conditions that can be converted into relaxed (R) because in the tool the results are 90% relax, then the suitability level is 90%. The results of the DASS 42 third respondent’s test were: normal depression, normal anxiety, and normal stress. The 3 scales have the same conditions, namely normal which can be converted into relaxed. In the tool the result is relaxed (R) 80% so that the suitability level is 80%. Furthermore, the results of the fourth respondent's DASS 42 tests were: normal depression, normal anxiety, and normal stress which were converted to relax, while the results obtained for the tool were 70% relaxed, so the suitability level of the tool was relaxed (R) 70%. Whereas for the fifth respondent the results of the DASS 42 test were as follows: normal depression, normal anxiety, and normal stress. Of the 3 scales, they have the same conditions that can be converted into relaxed, while the results for the tool are: 10% anxious, 40% calm, and 50% relaxed, so the suitability level of the tool is only 50% relax (R). The sixth respondent had DASS 42 test results: normal depression, normal anxiety, and normal stress, while the tool also shows 100% relaxed, so the suitability level of the tool and DASS is 100% relaxed (R). For the last respondent the results of the DASS 42 test were: normal depression, moderate anxiety, and mild stress. The 3 scales have different conditions but have 2 conditions that are close to each other, namely normal depression and mild stress which can be converted into relax. The results for the tool are 10% calm and 90% relaxed, so the level of suitability of the tool and DASS is relaxed (R) 90%.

Table 8. Comparison of tool test results with the DASS 42 test on respondents

No.	Respondent	DASS 42 Test	Tools	Suitability
1	Respondent 1	Normal depression Normal anxiety Normal stress	Calm=60% Relax=40%	40%
2	Respondent 2	Normal depression Normal anxiety Normal stress	Calm=10% Relax=90%	90%
3	Respondent 3	Normal depression Normal anxiety Normal stress	Calm=20% Relax=80%	80%
4	Respondent 4	Normal depression Normal anxiety Normal stress	Calm=30% Relax=70%	70%
5	Respondent 5	Normal depression Normal anxiety Normal stress	Anxiety=10% Calm=40% Relax=50%	50%
6	Respondent 6	Normal depression Normal anxiety Normal stress	Relax=100%	100%
7	Respondent 7	Normal depression Normal anxiety Normal stress	Calm=10% Relax=90%	90%
	The average suitability of the tool			74

3.6. Discussion

It can be concluded from the comparison of the data of 7 respondents who have done the test, the suitability value was 74%. Several factors, such as improper sensor placement, can cause this issue. When taking measurements, the respondent moves a lot which affects the results of the sensor reading, which causes an error in the reading of the respondent's condition [35], or when filling out the DASS 42 questionnaire was not in accordance with the conditions of the respondents at that time [15].

The results of stress level test that was conducted by author are different from the research conducted by [9], [10]. In previous research, it had been able to provide information about the condition of stress levels in humans, but the results obtained are not accurate because they did not use comparisons such as the DASS 42, which is a stress scale in psychology, but in this research author did.

4. CONCLUSION

Based on the data, the authors conclude that A stress detector designed using fuzzy logic as a decision maker method can work to detect stress with body temperature and blood pressure parameters with levels: relax, calm, anxiety, and stress. Experiments were also carried out by comparing the performance of the tool with the DASS 42 test, an accuracy of 74% was obtained. This could be caused when taking measurements, the respondent moves a lot which affects the results of the sensor reading, which causes an error in the reading of the respondent's condition, or when filling out the questionnaire DASS 42 was not in accordance with the conditions of the respondents at that time. Henceforth, validation of the performance of the tool will be carried out by involving a psychiatrist or psychologist.

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