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DESIGN AND BUILD A STRESS DIAGNOSIS SYSTEM BASED ON THE INTERNET OF THINGS (IOT) USING THE FUZZY LOGIC METHOD

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ABSTRACT
Stress is a situation in which an individual feels highly pressured. Numerous studies in the fields of psychology and health predominantly indicate that stress has a negative impact on health. An instrument for measuring stress levels using fuzzy logic methods is a tool used to gauge the level of anxiety or pressure experienced by individuals by observing parameters such as heart rate, body temperature, and blood pressure. Arduino Uno R3 is employed as a data processor, DS18B20 as a sensor for measuring body temperature, and MPX5050DP as a sensor for measuring heart rate and blood pressure. The results of these parameter measurements are then compared with a table that determines stress levels using the fuzzy method as a decision-making guide. Body temperature measurements using the DS18B20 sensor achieves an accuracy rate of 99.48%, while measurements of systolic and diastolic blood pressure and heart rate using the MPX5050DP sensor have accuracies of approximately 91.94%, 89.59%, and 96.7%, respectively. The calculation of stress levels using the fuzzy method operates effectively, with a success rate of 100%, in accordance with manually conducted fuzzy analysis.

Keywords: design; IoT; stress diagnosis system

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INTRODUCTION

Stress is a part of human life, meaning that humans will never escape the experience of feeling tension in their lives. The way individuals respond to stressful conditions also varies between one individual and another. This depends on the experience each individual has, his personality, and the conditions of his living environment. Furthermore, Acevedo, EO, & Ekkekakis, (2006) stated that stress can be caused, first: by innate characteristics which are hereditary predispositions and individual psychological limitations. Second, it is influenced by environmental factors such as living conditions and situations as well as individual past experiences. Thus the emergence of stress can be caused by factors from within the individual or factors from outside the individual.

Stress arises in line with events and life journeys that individuals go through and its occurrence cannot be completely avoided. In general, individuals who experience stress will disrupt their life cycle and feel discomfort. In fact, ongoing stress can harm oneself and others, so people need to understand the indications of stress symptoms, the impact of stress on individuals, know the causes of stress, and how to reduce it (Sukadiyanto, 2010). There are several symptoms that can be seen to determine the stress that is being experienced. someone like physical symptoms. Signs of human stress reactions include physical reactions, including headaches, heart pain or increased heart rate, difficulty sleeping, stomach ache, fatigue, cold sweats, lack of appetite and frequent urination (Abdullah, 2007). Stress can also trigger an increase in blood pressure with a mechanism that triggers increased adrenaline levels (Saputri, 2010). According to (Scott, 2021) stress includes four conditions, namely tense (s=stressed), anxious (t=tense), calm (c-=calm), and relaxed (r=relaxed). From various studies on stress from both the fields of psychology and health, most found that stress contributes negatively to health (Plaut, and Friedman, 1981; Baker et al, 1987 in Siboro, TS: 2008). This research proves that stress has the potential to increase a person's chances of being infected with disease and reduce the body's resistance. Another negative impact is that stress can cause feelings of discomfort if it cannot be managed. Therefore, we need a device that can check stress levels regularly to minimize the negative effects of this disease.

The development of technology is increasing, especially in the field of electronics. This development was marked by the discovery of sensors that can be used to measure physical quantities in the environment, such as body temperature, heart rate, humidity sensors, pressure sensors, and so on. To process data from these sensors, various types of microcontrollers have also been developed as components or processing tools. Technological developments in the field of electronics have also encouraged the automation of electronic devices. In this research the author designed and built a tool that is able to measure human stress levels automatically. The variables measured are heart rate, body temperature, skin moisture and blood pressure. These four variables are processed with sensors and the sensor values will be sent via the wireless network to the database. The results of sensor processing can be seen through the application.

METHOD

This research is a type of exploratory descriptive research with a quantitative approach. Descriptive research aims to describe the nature of something that is taking place when the research is carried out and examines the causes of a particular symptom. Exploratory descriptive research aims to describe the state of a phenomenon. This research is not intended to test a particular hypothesis, only to describe what a variable, symptom or situation is (Arikunto.S, 2010).

RESULTS

Testing the Arduino Uno R3 Board

Testing the Arduino Uno R3 board is carried out by entering the program on.

Table 1.
Arduino Digital Pin Output Test Results (Pin 8)

Pin Output Measurement Digital (V)	Expected Value (V)	Errors (%)
4.99	5	2
5.02	5	0.39
4.99	5	2
4.98	5	0.4
5.02	5	0.39
Amount		5.18%
Average (%)		1.03%

Based on the tests above, it can be concluded that the Arduino Uno R3 board can work well, with an average error rate of 1.03%.

LCD Testing

LCD testing is carried out by entering the program into the Arduino Uno R3 board, then looking at the LCD display to see whether it matches the program created:

Figure 1. LCD Test Results

MPX5050DP Pressure Sensor Testing

MPX5050DP Pressure Sensor Testing Pressure sensor testing is carried out by comparing the output results of the pressure sensor used in the system, namely the MPX5050DP, with a digital tensimeter.

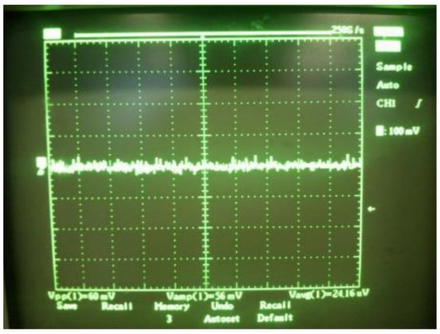

Figure 2. Sensor Output Without Filter and Amplifier

Figure 2 is the pressure sensor output without using a filter and amplifier. The oscilloscope is set at Volt/Div 100 mV, and Time/Div 200 ms. This output is very small, namely around 60 mV Vpp, so it cannot be directly used to measure blood pressure and heart rate

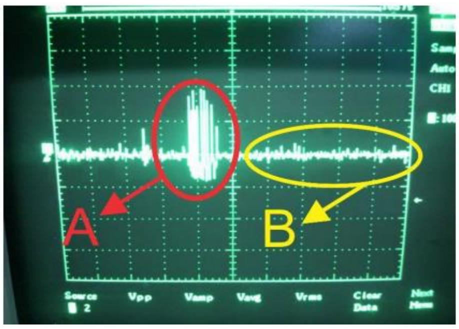

Figure 3. Sensor output without filter and amplifier when the handcuff is pumped

Figure 3 is the sensor output without filter and amplifier when the handcuff is pumped. In the picture, it can be seen that there is an oscillation signal produced by the air pump pressure on the handcuff (pointer A), then when the handcuff starts to deflate the measured signal looks similar to before pumping (pointer B) so that blood pressure measurements cannot be carried out directly without the addition of a filter circuit. and amplifiers.

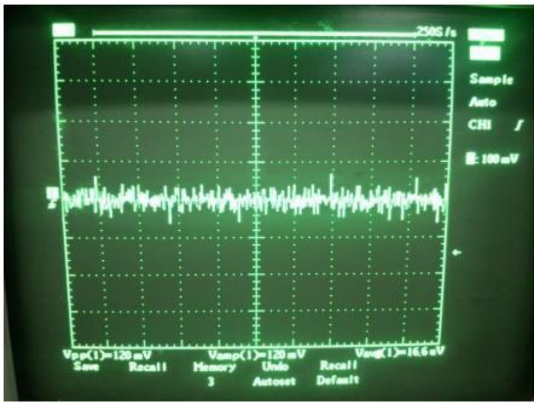

Figure 4. Sensor output after filter and amplifier are installed

Figure 4 is the sensor output after installing the filter and amplifier. The oscilloscope is set at Volt/Div 100 mV, and Time/Div 200 ms. The resulting output is around 120 mV Vpp.

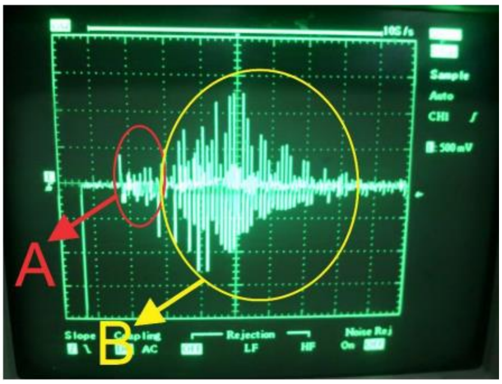

Figure 5 Sensor output after installing a filter and amplifier when the handcuff is pumped

Figure 5 is the sensor output after installing the filter and amplifier when the handcuff is pumped. Pointer A is a signal when pumping air into the handcuff. When the pumping is stopped and the handcuff slowly deflates, the signal is ready to be used to calculate blood pressure and heart rate (pointer B).

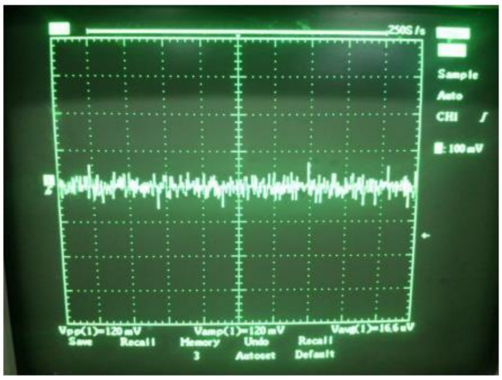

Figure 6. Sensor output after filter and amplifier are installed

Figure 6 is the sensor output after installing the filter and amplifier. The oscilloscope is set at Volt/Div 100 mV, and Time/Div 200 ms. The resulting output is around 120 mV Vpp.

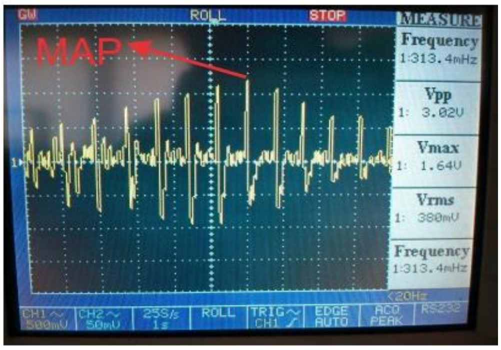

Figure 7. Sensor output when the handcuff starts to deflate 1

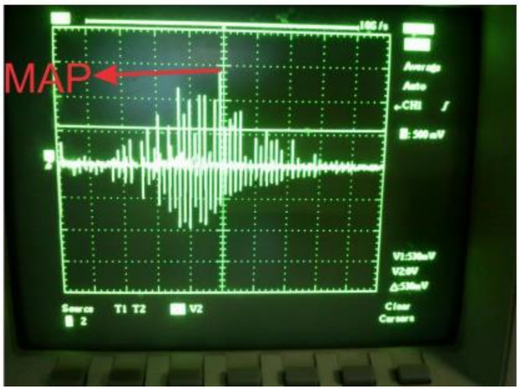

Figure 8 Sensor output when the handcuff starts to deflate 2

Figure 7 and Figure 8 are the sensor output when the air in the handcuff begins to be slowly expelled. In this image you can see the signal starting to rise until it reaches the highest point (Mean Arterial Pulse), then slowly falls again. This MAP signal is used to find systolic and diastolic blood pressure values.

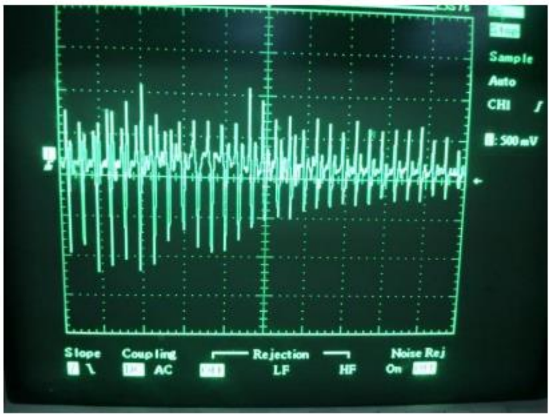

Figure 9. Heartbeat Signal

Figure 9 is the output of the heartbeat signal from the pressure sensor. To get the heartbeat value, you need to take the pressure sensor output data with a sampling time of 100 milliseconds for 15 seconds. A threshold of 3.66 Volts or a value of 750 is used when converted into digital data. (The threshold value was obtained from ± 50 experiments), based on the experimental results it can be concluded that if the measured data exceeds the threshold value, then at that time the heart beats once, so that the heart rate value increases every time a value is obtained that exceeds the threshold.

Figure 10, Figure 11, and Figure 12 are a comparison of measurement results using the Omron HEM-7111 brand digital tensimeter with the designed pressure sensor.

Figure 10. Blood Pressure and Heart Rate Test Results

Figure 10 shows the measurement results from a digital sphygmomanometer for systolic, diastolic and heart rate with values of 131, 77 and 77, while the pressure sensor shows 124, 80 and 80.

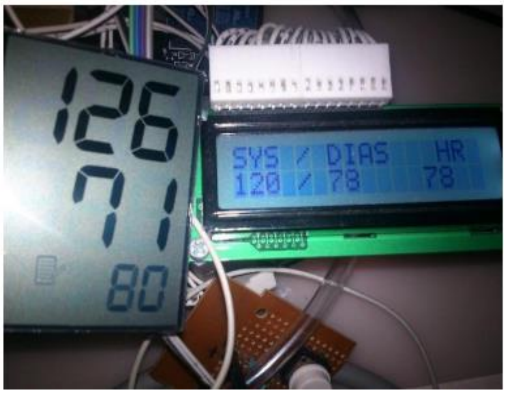

Figure.11 Blood Pressure and Heart Rate Test Results 2

Figure 11 shows the measurement results from the digital sphygmomanometer for systolic, diastolic and heart rate with values of 126, 71 and 80, while the pressure sensor shows 120, 78 and 78.

Figure 12. Blood Pressure and Heart Rate Test Results 3

Figure 12 shows the measurement results from the digital sphygmomanometer for systolic, diastolic and heart rate with values of 115, 70 and 66, while the pressure sensor shows 100, 65 and 70.

Temperature Sensor Testing

Testing of the DS18B20 temperature sensor was carried out by testing the temperature sensor output and the results were compared with a digital thermometer.

Figure 13. Testing of the DS18B20 Temperature Sensor and Digital Thermometer

Figure 13 shows the measurement results of a Onemed brand digital thermometer and a DS18B20 temperature sensor with values of 32.7ºC and 32.38ºC.

DISCUSSION

After the tool has been designed and built, a tool testing process will be carried out, to find out whether the tool built is suitable and can function according to the design carried out. First we carry out systolic, diastolic and heart rate pressure testing, next we measure the temperature sensor, carry out fuzzy method testing, and finally we test the system as a whole.

Systolic Pressure, Diastolic and Heart Rate Testing

Results of measuring systolic, diastolic and heart rate pressure with 15 measurements. Table 2 is the result of measuring systolic pressure, diastolic pressure and heart rate using 15 measurements.

Table 2.
Blood Pressure and Heart Rate Measurement Results

Measurement Digital Tensiometer			MPX5050DP Pressure Sensor Measurement			*Errors (%)*		
Systole (mmHg)	Diastole (mmHg)	Beat (bpm)	Systole (mmHg)	Diastole (mmHg)	Beat (bpm)	*Error*Systole	*Error*Diastole	*Error*Beat
131	77	77	124	80	80	5.34	3.89	3.89
126	71	80	120	78	78	4.76	9.85	2.5
115	70	66	100	65	70	13.04	7.14	6.06
108	64	59	110	71	60	1.85	10.93	1.69
113	67	60	125	81	60	10.61	20.89	0
102	65	72	111	72	70	8.82	10.76	2.77
117	70	58	118	76	60	0.85	8.57	3.44
120	69	59	126	82	56	5	18.84	5.08
119	71	81	115	74	80	3.36	4.22	1.23
118	67	81	100	65	84	15.25	2.98	3.70
115	77	81	90	58	80	21.73	24.67	1.23
123	70	77	110	71	80	10.5	1.42	3.89
112	65	87	115	74	84	2.67	13.84	3.44
111	66	85	120	78	76	8,10	18.18	10.58
110	65	80	122	79	80	9.09	0	0
Amount						121.03	156.18	49.5
Average*error*(%)						8.06%	10.41%	3.30%

Based on the tests above, it can be concluded that measuring blood pressure and heart rate using the MPX5050DP pressure sensor obtained an average error rate of 8.06% for systolic pressure, 10.41% for diastolic pressure, and 3.30% for heart rate. Thus, the accuracy level of the MPX5050DP pressure sensor module can be obtained at 91.94% for systolic pressure, 89.59% for diastolic pressure, and 96.7% for heart rate.

Temperature Sensor Measurement

DS18B20 temperature sensor measurement results with 10 measurements. Table 3 is the result of measuring the DS18B20 temperature sensor with 10 measurements.

Table 3.
DS18B20 Temperature Sensor Measurement Results

Digital Thermometer (ºC)	DS18B20 Temperature Sensor (ºC)	*Error*(%)
34.2	34.50	0.87
34.6	34.88	0.81
34.2	34.38	0.53
34.4	34.0	1.16
32.7	32.38	0.98
34.75	34.9	0.43
35.0	35.20	0.57
34.2	34.25	0.14
33.2	33.50	0.90
34.4	34.55	0.44
Amount		5.22%
Average*error*(%)		0.52%

Based on the tests above, it can be concluded that the DB18B20 temperature sensor has an average error rate of 0.52%. In this way, the accuracy level of the DS18B20 temperature sensor can be obtained at 99.48%.

Fuzzy Method Testing

Fuzzy method testing is carried out by entering heart rate, blood pressure and body temperature parameter data into the fuzzy system that has been programmed on Arduino and the results are compared with manual fuzzy system calculations. The following are the results of testing the fuzzy system created.

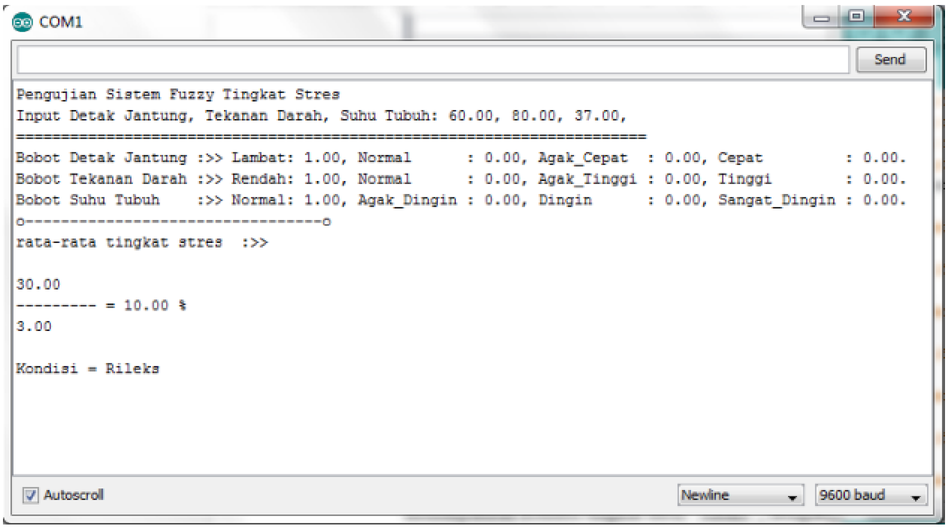

Figure 14. Fuzzy Method Test Results 1

Figure 14 is one of the fuzzy system test results with input heart rate of 60 bpm, blood pressure of 80 mmHg, and temperature of 37oC. The results show that the stress level is "relaxed", with a stress level percentage of 10%. The test results are in accordance with manual fuzzy analysis.

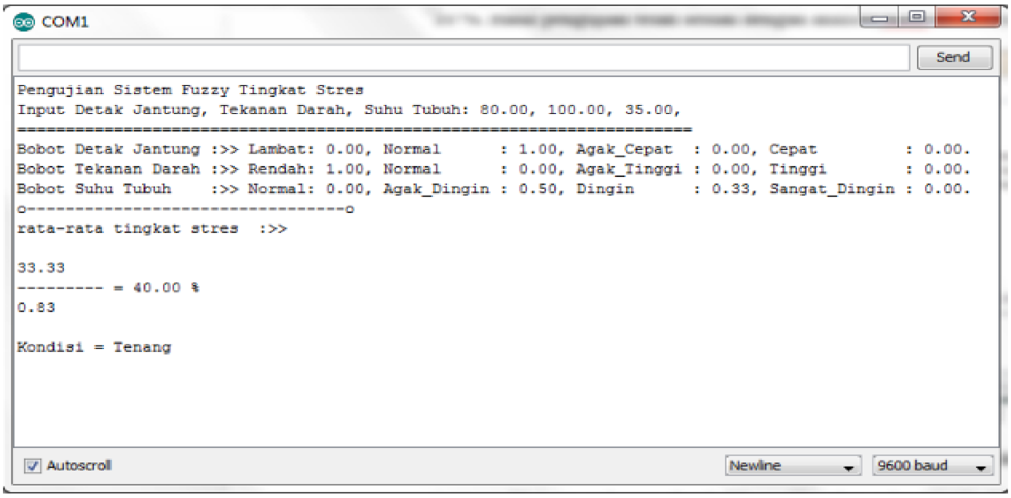

Figure 15. Fuzzy Method 2 Test Results

Figure 15 is one of the fuzzy system test results with input heart rate of 80 bpm, blood pressure of 100 mmHg, and temperature of 35oC. The results show a "calm" stress level condition, with a percentage of stress levels.

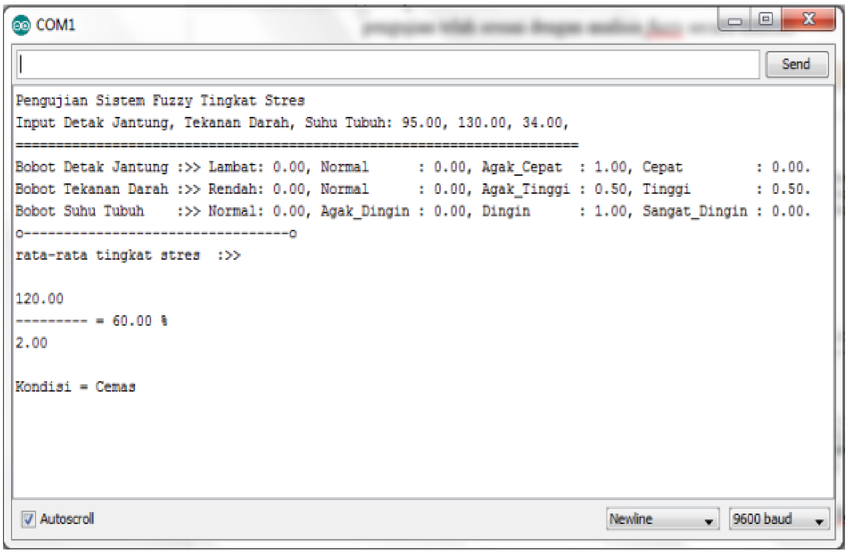

Figure 16. Fuzzy Method Test Results 3

Figure 16 is one of the fuzzy system test results with input heart rate of 95 bpm, blood pressure of 130 mmHg, and temperature of 34oC. The results show that the stress level is "anxious", with a stress level percentage of 60%. The test results are in accordance with manual fuzzy analysis.

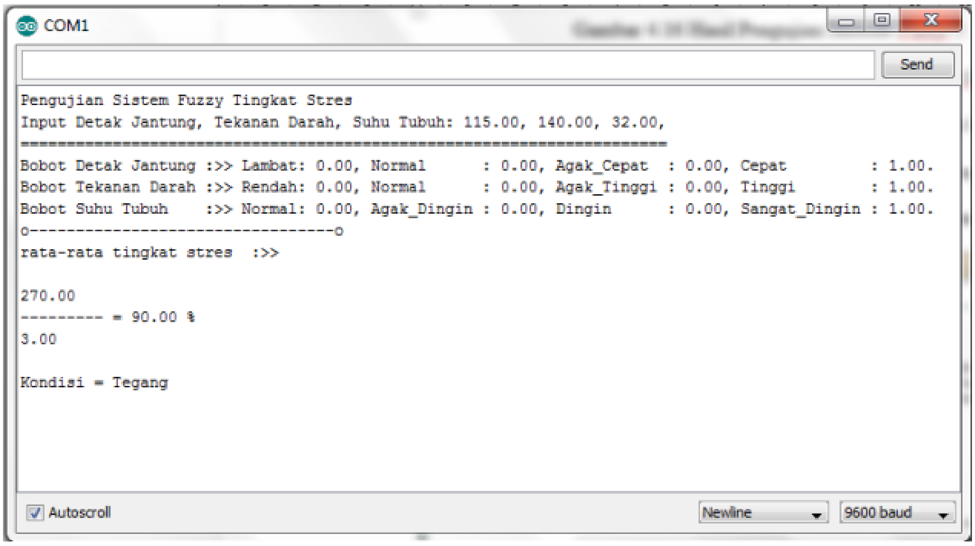

Figure 17. Fuzzy Method Test Results 4

Figure 17 is one of the fuzzy system test results with input heart rate of 115 bpm, blood pressure of 140 mmHg, and temperature of 32oC. The results show that the stress level condition is "tense", with a stress level percentage of 90%. The test results are in accordance with manual fuzzy analysis. From the results of testing the fuzzy system, it can be concluded that the fuzzy system created is in accordance with manual fuzzy analysis.

Overall System Testing

Overall system testing is carried out by measuring the stress level of the subject. This test aims to determine the system's ability to measure blood pressure, heart rate and body temperature, so that conclusions can be drawn regarding human stress levels. Table 4 is the result of overall system testing with 5 measurements

Table 4.
Overall System Test Results

Heart rate	Systolic Pressure	Body temperature	Stress level	Results
88	122	35.19	48.24% (Calm)	According to manual calculations
100	124	31.1	75% (Worried)	According to manual calculations
80	98	32.19	40% (Calm)	According to manual calculations
68	110	35.0	31.28% (Calm)	According to manual calculations
88	126	32.7	63.53% (Worried)	According to manual calculations

From the overall system testing, it can be concluded that the system runs well in measuring stress levels in humans, and the results of calculating stress level conditions are in accordance with manual fuzzy analysis.

CONCLUSION

Based on the test results, the following conclusions were obtained: 1. The accuracy level of the DS18B20 sensor for measuring body temperature was 99.48%, this result is a comparison with the Onemed brand digital thermometer. Meanwhile, the accuracy level of the MPX5050DP sensor for measuring systolic pressure was 91.94%, diastolic pressure was 89.59%, and heart rate was 96.7%. The results obtained are a comparison with the Omron

HEM-7111 digital tensimeter which has an error rate of 5%. 2. Calculation of stress levels using the fuzzy method went well with a success percentage of 100% according to manual fuzzy analysis. Body temperature measurement using the DS18B20 sensor has a very good accuracy rate of 99.48%. Meanwhile, when measuring systolic and diastolic blood pressure, the error produced is higher compared to the results of measuring heart rate, even though the same pressure sensor is used. Factors that can influence the results of blood pressure measurements include the size of the handcuff and the arm being inappropriate, the position of the handcuff on the arm must be correct, namely the handcuff is wrapped around 1-2 cm above the wrist of the elbow, and must be parallel to the heart, and the arm must be relax during the measurement. Overall the system can run well in measuring stress levels and the fuzzy system used can run as expected.

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