MONITORING OF HEALTH CONDITIONS USING A FUZZY ALGORITHM

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ABSTRACT

Maintaining a healthy body is the duty of each of us, both young and old. To maintain a healthy body can be done in various ways such as exercise and eating healthy foods. Health according to the World Health Organization (WHO) is perfect health, physically fit, free from disease and disability, and spiritually and socially healthy. A person's health can be determined through many factors. To find out whether the health intensity has been reached, an indicator of pulse rate and body temperature that is healthy and in accordance with normal human standards can be used. To know a person's health, one can measure the pulse in certain parts such as the wrist, but this is not necessarily effective and accurate. So body temperature is a vital condition that must be monitored to avoid hypothermia and hyperthermia. The health monitoring system is a system designed to determine the user's health condition by measuring the pulse and body temperature which is then used as a decision-making parameter by applying fuzzy algorithm using the internet of things (IOT). Fuzzy algorithm is used for decision making from a logic that has a fuzzy value between true or false. The author uses 2 input sensors, namely MLX90614 (temperature) and pulse sensor as parameters for determining health. The HC-SR04 sensor (distance) is used to turn on the 5volt pump which functions as an automatic hand sanitizer. The 16x2 LCD functions to display the output, namely Healthy, Unhealthy, Sick. The TTV standard is used as a reference for membership limits.

Keywords: IOT, MLX90614, pulse sensor, HC-SR04, LCD, fuzzy algorithm

BACKGROUND

Maintaining a healthy body is the duty of each of us, both young and old. To maintain a healthy body can be done in various ways such as exercise and eating healthy foods. Health according to the World Health Organization (WHO) is perfect health, physically fit, free from disease and disability, and spiritually and socially healthy. A person's health can be determined through many factors. To find out whether the health intensity has been reached, an indicator of pulse rate and body temperature that is healthy and in accordance with normal human standards can be used. To know a person's health, one can measure the pulse in certain parts such as the wrist, but this is not necessarily effective and accurate. So body temperature is a vital condition that must be monitored to avoid hypothermia and hyperthermia.

The health monitoring system is a system designed to determine the user's health condition by measuring the pulse and body temperature which is then used as a decision-making parameter by applying fuzzy algorithm using the internet of things (IOT). Fuzzy algorithm is used for decision making from a logic that has a fuzzy value between true or false.

The development of technology in the health sector currently is very beneficial and effective. One of the technologies that is developing rapidly today is the Internet of things (IoT). IoT technology is a concept where a certain object can transmit data over a network and without any human-to-human or human-to-computer interaction. IoT has begun to develop rapidly since the availability of wireless technology, micro-electromechanical systems (MEMS), and the internet. IoT is also often identified with RFID as a communication method. However, IoT can also include other sensor technologies such as wireless technology and QR codes. IoT technology can facilitate the remote monitoring process and the following are some similar studies that have been carried out.

In research on Temperature Measurement with Arduino-Based Infrared Temperature Sensor [1]. This study aims to determine the temperature conditions of an object using devices such as Arduino Uno, memory card, LCD, ATMEGA28 microcontroller, and MLX90614 sensor. An Arduino-based sensor, the MLX90614 sensor, measures the temperature of an object, namely the temperature of ice cubes, and the temperature of hot water. The use of the LCD in this study is to display the temperature in Celsius, and the memory card to store data in .txt. The temperature monitoring tool has succeeded in approaching the results of temperature measurements with alcohol and has a significant deviation. In addition, the results are accurate and almost close to temperature measurements through an alcohol thermometer reference. The drawback of this research is that it is necessary to pay attention to the placement of the sensor with the object so that infrared reflection is better.

In the research entitled Design of Monitoring and Control System of Liquid Heating Temperature Using Infrared Sensor which aims to measure the temperature of liquid with infrared sensor [2]. This research uses tools and devices such as Arduino Uno R3 Microcontroller, LCD, Relay, buzzer, keypad, and MLX90614 sensor. The system works on the principle of sensing infrared radiation emitted by objects. Infrared radiation is converted into electrical signals which are then processed by the Arduino Uno R3 microcontroller. The tool works with accurate and good results, namely successfully reducing the influence of hotplate radiation and the environment, and realtime sensor readings. This study has the best linearity and accuracy of measurement results with an accuracy of 99.24% and an error of 0.76%, while the drawback of this study is that there is an error at a distance of 5mm, so that the selected sensor placement is at a distance of 4mm.

Research in 2016 on Prototype Temperature Monitoring System Using Arduino Uno R3 With Wireless Communication [3]. The purpose of this research is to monitor the temperature of a product at the PT. Krakatoa in Poso. This research uses 433Mhz RF Module, Arduino Uno, Lcd, and MLX90614 sensor. The steel plate temperature which is read by the MLX90614 sensor via Arduino Uno is then transmitted to the 433Mhz RF Module via radio waves. The steel plate reading goes well and the process can be more effective because the crane operator already knows the temperature. The results of this study are quite accurate even though there is an average temperature difference with the thermogun of about 2.58 C.

In the research titled Study Application of MLX90614 Sensor as Arduino and Labview-Based High Temperature Meter which aims to determine the dependence of temperature measurement on distance and to determine the effect of the environment on temperature measurement with the MLX90614 sensor [4]. This research uses tools and materials such as Arduino Uno, Microcontroller, and Labview. Infrared radiation is captured by the MLX90614 sensor and then converted to measure the temperature of an object. This research utilizes the heat radiation generated by the heating element to observe the temperature distribution around the heater. The design of a non-contact high temperature measurement tool using the Arduino and Labview-based MLX90614 sensor can be implemented and the measurement area is more protected from the outside environment by wearing a shield. The results of the measurements of this study can be displayed serially or graphically. This study has a drawback, namely the distance correction factor can be formulated with a formulation based on experimental results.

In a study titled Contact and Non Contact Body Temperature Thermometer Test [5]. This study aims to test the thermometer by comparing it with a standard thermometer using tools and materials such as Arduino ATMega 328, LCD, DS18B20 sensor, and MLX90614 sensor. Both sensors produce digital data output on the LCD. The results of temperature measurements in digital form are displayed in a 2x8 LCD. The drawback of this research is the need to add a sample data storage system and make a smaller box design to make it more convenient to use.

Research in 2016 on the Design of a Web-Based Dairy Cattle Temperature Data Acquisition System which aims to determine the health of dairy cows through temperature measurements or build a system that can diagnose diseases in dairy cows with temperature parameters [6]. This research uses tools and materials such as MLX90614 sensor, buzzer, microcontroller and wifi module, Local Area Network (LAN), Internet Layer (IP), MYSQL, and Arduino MegaAT. The MLX90614 sensor is an infrared temperature sensor that is designed complete with signal conditioning so that it is directly captured by Arduino Uno as a data sender with a 12c bus. The system in this study works well and can minimize the use of time in diagnosing dairy cow disease with temperature parameters. The results of the implementation of this study are intended for modern dairy cows with a high amount of lactase. The drawback of this study is that it has an average margin of error of 6.63%.

In a study entitled Designing a Non-Touch Digital Thermometer aims to design a prototype thermometer that can be used to detect body temperature without touching the user [7]. This research uses tools and materials such as MLX90614 sensor, LCD, Arduino Uno Microcontroller, SCL (Serial Clock), SDA (Serial Data). The Mlx90614 sensor reads the temperature by emitting infrared light to the target object to produce an analog signal output. The data obtained from the sensor is processed by Arduino Uno R3 to produce output in the form of temperature in Celsius. The highest precision in temperature measurement is at a distance of 15 cm and good accuracy is at a distance of 10 cm. The highest precision is at a distance of 15 cm with a value of 98.90% to 99.50%, and a good accuracy value is obtained at a distance of 10 cm with a value of 98.70% to

99.92%. The results of this study are quite accurate and very useful in reducing the touch with the user, and the drawback of this study is that there is still a certain distance to get an accurate value.

Based on the research that has been done, the conclusions obtained include: 1. The design of the instrumentation tool uses the DS18B20 sensor as a temperature sensor and a pulse sensor as a heart rate sensor. The tool will detect hypothermia if the temperature and heart rate sensors are less than 35.5 C and 60 BPM, while hyperthermia if the temperature and heart rate sensors are more than 37.5 C and 100 BPM. The graph sensor produces a linear regression equation, the temperature sensor produces a regression of 0.98, while the heart rate sensor produces a regression of 0.9951. 2. In making decisions using fuzzy logic using the Mamdani fuzzy method which will detect hypothermia if the temperature is cold and the heart rate is slow, while hyperthermia if the temperature is hot and the heart rate is fast according to the basic rules that have been made. In testing fuzzy logic is able to produce an error percentage of 0.076% when testing on matlab and actually. 3. On the results of testing on patients, we tested 10 patients and the results of the detection of the equipment from the medical staff showed the same of the 10 patients, so it can be said that the instrument that has been made shows a 100% success rate [8].

Research conducted by Ezekiel Hansel Hendratno, Noor Cholis Basjaruddin, Endang Darwati [9], the measuring instrument is used by the user attaching the NFC card to the device or entering the name and id on the HMI, then installing the tension meter and temperature sensor then standing in the place provided, this tool can determine height, weight, body temperature, heart rate, and blood pressure. The user's alcohol content can be measured by the user blowing the alcohol sensor which then the data is displayed on the HMI (Human Machine Interface) automatically and will also be displayed on the Liquid Crystal Display (LCD). HMI can store measurement data in the form of a database on the MS. Access. After the measurement of body parameters is complete, then the data is processed using the Sensor Fusion method by combining height and weight to produce a body mass index classification such as very thin, thin, normal, fat or very fat. The results of body temperature measurements are classified into normal body temperature, hypothermia or hyperthermia. The heart rate measurement results were classified into very good, good, adequate or poor heart rate. The results of blood pressure measurements were classified as optimal, normal, normal-high, level 1 hypertension, level 2 hypertension, level 3 hypertension, and systolic hypertension. The results of the classification of alcohol measurements into alcohol positive or negative status. After getting the results of the classification, all data are classified into 3 major groups of health status, namely optimal conditions, healthy conditions with a description of unhealthy conditions, immediately contact a doctor. The health status measurement system is realized with mechanics that can be folded into a height of 15 cm, a length of 55cm and a width of 55cm and a measurement length of 60 seconds with an accuracy rate of 99.8% weight measurement, 99.7% height, 98 body temperature, 03%, heart rate 83%, blood pressure 87% and alcohol status 56%. All measurement data can be stored in a database using Microsoft Access and displayed on HMI using Microsoft Visual Studio and updating data stored on NFC [9].

A study in 2019 entitled Gamer Condition Monitoring Tool aims to monitor and remind gamers to pay more attention to their health [10]. By making this condition monitoring tool that will focus on two parameters, namely pulse rate and body temperature. This research works when the gamer's body temperature is below 35 degrees Celsius, in this condition gamers can get hypothermia caused by being in a cold place for too long and not wearing warm clothes or the heartbeat is in an abnormal condition. SMS to their parents. This system uses tools and materials such as Arduino Uno ATMega328, LCD, 12Cmodule, sensor MLX90614, pulse sensor, DF player mini, SIM900A, and RTC (real time clock). Based on the problems above, it is necessary to monitor the condition of gamers. The tool uses Arduino Uno to work as a device controller, the MLX90614 temperature sensor works to read body temperature, the pulse sensor works to read the heart rate. The output issued by this system is in the form of text, sms, and voice. In testing the MLX90614 sensor it can be seen that the test is functioning properly, the sensor test is measured from a distance of 1 cm to 5 cm and compared to a digital thermometer there is a difference between 2.11 C to 5.55 C. This study has drawbacks at a certain distance the sensor still has a margin of error.

In a study entitled Monitoring Water Temperature and Fan Cooling Water Speed in a Binary Cycle Geothermal Power Plant, the aim is for a remote monitoring system and is very helpful for monitoring the temperature and rotational speed of cooling water [11]. To monitor a temperature and rotational speed of cooling water, it is not effective to use the manual method, especially if it is from a very far distance. For this reason, a system is created that can monitor a system that is displayed on the website, where the temperature monitoring system and cooling water rotation speed can be monitored in real time on the website. Data on temperature and rotational speed of cooling water is sent to the database and stored. This research uses Internet of things (IoT) tools and materials, monitoring system, website, hardware (ESP8266 Microcontroller, MLX90614 sensor, Infrared transmitter), Database. The method in this research includes the design of hardware and software. Hardware design is the design design and design of the connecting circuit of the system supporting components. Software development includes monitoring system workflow diagrams as well as programming the MLX90614 sensor and IR sensor on Wemos D1 R2, database programmer and website design using MYSQL. Based on the research conducted, it can be concluded that the cooling water fan temperature and speed monitoring system with Wemos D1 R2 has been running well, where the cooling water fan temperature and speed data sent to the web server at 09.00 Am the object temperature is at 49 C, while the speed fan cooling water 0 is caused by cooling water is off. Comparison testing between sensors and measuring instruments aims to compare the analysis between the sensors used, so that they can find out the error results that have been obtained. The difference between the results of the study and the thermometer is 3 Celsius. This research has shortcomings in website programming techniques and in the future it is expected to develop sensors.

In a study entitled Heart Rate Recording System Based on Pulse Heart Rate Sensor on Fingers [12]. Aims to determine the accuracy of the pulse heart rate sensor in detecting the heart rate on the fingers, where the next stage of this system will be used to record the patient's heart

rate all day in a state of activity. This system is designed using a pulse heart rate sensor module that is connected to the Arduino Nano microcontroller. Heart rate data is recorded on the SD Card module. The measurement results of this system are compared with the measurement results of the Oxymeter tool. Testing is done by measuring the heart rate on the middle finger with an Oxymeter and the index finger with this system. The test was carried out once each on 2 fingers of the right hand and left hand of 30 participants with an age range of 18-23 years. The test results show the average error of the accuracy of this system is 2 bpm against the oximeter with the largest difference being 5 bpm.

This research uses pulse sensor as input for pulse rate and MLX90614 sensor for body temperature input. The HC-SR04 sensor is used as a distance input to trigger the pump to automatically dispense hand sanitizer. This project uses a 16x2 I2C LCD as output to display the health condition of the object. All projects are processed into one on Arduino Uno using fuzzy algorithms.

RESEARCH METHODOLOGY

Collecting Data

This study includes data from various health conditions, including testing with body temperature and pulse rate, as well as optimal and accurate testing. The purpose of this test is to see if the tool/sensor is operating properly.

Implementation and Analysis

Programs are created and uploaded using Arduino Uno. MLX90614 sensor (temperature), pulse sensor (pulse rate) as input to detect the object's health condition in accordance with what has been determined through body temperature and pulse rate, then the input data will be processed using a fuzzy algorithm with 9 rules to detect a person's health condition through parameters of body temperature and pulse rate. To obtain data for this study, the following and sensors were tested:

1. Test the body temperature sensor.
2. Test the pulse sensor.
3. Testing automatic hand sanitizer.
4. Health monitoring system testing.

Finally, In order to find conclusion, researchers looked at a person's health condition through the parameters of body temperature and pulse rate. This data will be recorded and used to evaluate the sensors and the device.

ANALYSIS AND DESIGN

Hardware

Gambar 1. Arduino Uno

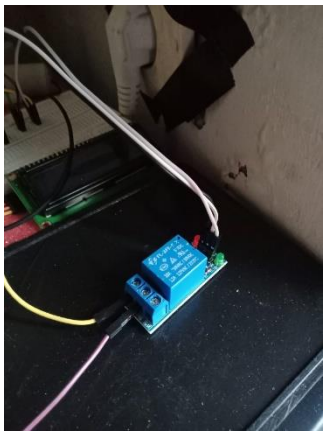
Arduino Uno is a microcontroller board based on Atmega328 (datasheet). It has 14 input pins from digital output where 6 input pins can be used as PWM outputs and 6 analog input pins, 16 Mhz crystal oscillator, USB connection, power jack, ICSP header, and reset button. To support the microcontroller so that it can be used a USB or power cable with AC to DC adapter or battery to run it. Uno is different from all previous boards in terms of USB-to-serial connection, namely using the Atmega8U2 feature which is programmed as a USB-to-serial converter, in contrast to the previous board which uses the ship's FTDI USB-to-serial driver. The name "Uno" means one in Italian, to mark the launch of Arduino 1.0. Uno and veri 1.0 will be the reference versions of Arduino. The Uno is the latest in a series of Arduino USB boards, and serves as a reference model for the Arduino platform, for comparison with previous versions.

Gambar 2. Sensor MLX90614, Pulse sensor, HC-SR04

To detect the pulse rate, the writer uses a pulse sensor. The pulse sensor is used to facilitate the incorporation of pulse measurement with data applications into its development. The pulse sensor works well at 5V and 3.3V in the microcontroller. There are 3 male wire terminals (ground, power, and data) with standard connectors. The MLX90614 sensor is a sensor that is used to measure temperature by utilizing infrared radiation. Infrared MLX90614 serves to detect the intensity of infrared radiation emitted by the object / test object. Because this sensor is not in physical contact with the test object / object, this sensor has a wide measurement range from -70 degrees Celsius to +380 degrees Celsius. Infrared radiation is a part of the electromagnetic spectrum that has a wavelength from 0.7 to 1000 microns. However, only 0.7-14 microns can be used to measure temperature.

The HC-SR04 sensor is used as input for the pump for automatic hand sanitizer. The HC-SR04 sensor is an ultrasonic sensor module which is usually used for distance measuring

devices. On the HC-Sr04 sensor there is a pair of ultrasonic transducers, one of which functions as a transmitter whose job is to convert the electrical signal into an ultrasonic sound wave pulse signal with a frequency of 40KHz, and the other transducer serves as a receiver whose job is to receive ultrasonic sound wave signals.



Gambar 3. Relay

Relay is a switch (Switch) which is operated electrically and is an Electromechanical component (Electromechanical) which consists of 2 main parts, namely Electromagnets (Coil) and Mechanical (a set of Switch Contacts/Switches). Relays use the Electromagnetic Principle to drive the Switch Contacts so that with a small electric current (low power) they can conduct higher voltage electricity. For example, a Relay that uses 5V and 50 mA Electromagnets is able to move the Armature Relay (which functions as a switch) to conduct 220V 2A electricity.

The relay is useful as a 5 volt pump switch to automatically dispense hand sanitizer with object input at less than five centimeters.

Gambar 4. LCD 16x2

The 16x2 LCD functions to display digital value output from the mlx90614 sensor and pulse sensor, and displays health conditions, namely healthy, unhealthy, sick.

Algorithm Fuzzy Logic Sugeno

Fuzzy logic is a logic that has a value of fuzziness between true or false. Rules (algorithms) are used to create predictive models. It provides a new way to explore and understand data. Although fuzzy logic was developed in America, it is more popular and widely applied by Japanese practitioners by adapting it to the control field. One of the reasons is because western people tend to view an issue as black and white, yes and no, guilty and innocent, or equivalent to the world of Aristotle's binary logic, while eastern culture is more accepting of the "gray" or fuzzy world. Fuzzy logic allows membership values between 0 and 1, gray levels as well as black and white, and in linguistic terms, uncertain concepts such as little, fair, and very.

Fuzzy logic can be used in the fields of control theory, decision theory, and some areas of management science. The advantage of fuzzy logic is that it is able to process linguistic reasoning, so that in its design there is no need for mathematical equations from the object being controlled. Fuzzy logic is generally applied to problems that contain elements of uncertainty, imprecision, noisy, and so on. Fuzzy logic bridges precise machine language with human language that emphasizes meaning or meaning and is developed based on natural human language.

To design a fuzzy system, it is necessary to do the following steps:

1. Define the functional and operational characteristics of the model.
2. Decompose model variables into fuzzy sets.
3. Create fuzzy logic rules.

Fuzzy Sugeno method is a fuzzy inference for rules that are represented in the form of IF-THEN, where the output (consequent) of the system is not a fuzzy set, but a constant or linear equation. This Sugeno method is a fuzzy method that has proven to be effective when dealing with complex non-linear systems, which are very difficult for synthetic analysis.

IMPLEMENTATION AND RESULTS

System testing is the process of trying or executing hardware and software to test whether the system is running as expected. The test was carried out on 10 different respondents with adult age parameters. Then an evaluation process is carried out if the system does not match what the researcher expects. The test carried out is to compare the MLX90614 sensor and pulse sensor with a thermogun and heart rate to determine the accuracy of the sensor in determining decisions in determining conditions through a fuzzy algorithm. Result of pulse sensor, heartbeat and temperature test are presented in Table 1 and Table 2.

Table 1. Pulse sensor and heartbeat measurement results (averaged over 5 trials)

Testing	Heartbeat (BPM)	Pulse Sensor (BPM)	Difference (BPM)
Respondent #1	84.2	86.4	-2.2
Respondent #2	83.4	83.6	-2
Respondent #3	75	75.8	-2
Respondent #4	73.6	72.8	-2
Respondent #5	76.6	74.6	-2
Respondent #6	78.6	78.8	-1
Respondent #7	96.8	97.6	-0.8
Respondent #8	97	98	-1
Respondent #9	76.8	78	-1.2
Respondent #10	77.4	77.6	-0.2

Table 2. Temperature sensor (MLX90614) and thermogun measurement results (averaged over 5 trials)

Testing	Heartbeat (BPM)	Pulse Sensor (BPM)	Difference (BPM)
Respondent #1	36.4	36.6	-0.3
Respondent #2	36.6	36.6	-0.6
Respondent #3	36.5	36.4	-1.4
Respondent #4	36.5	36.5	-0.18
Respondent #5	37.04	37.1	-0.14
Respondent #6	36.52	36.66	-0.14
Respondent #7	36.7	36.8	-0.1
Respondent #8	36.64	36.64	0
Respondent #9	76.8	78	-1.2
Respondent #10	36.72	36.76	-0.04

As shown in table 3 temperature and pulse data were obtained from 5 different respondents. The temperature and pulse values are in accordance with the sensor calibration, and the fuzzy Sugeno algorithm runs according to the specified rules in the form of Sehat, Kurang Sehat, Sakit. Throughout the results given by various sensors, we can see that most of the measurements are precise enough to be used for determining the subject's health.

Given the results form the sensors, we can now determine the health using fuzzy logic. Table 4 is a simulation of data for comparison of algorithms that produce sick and unhealthy conditions.

Table 3. Health Monitoring System Test Results (averaged over 5 trials)

Testing	MLX90614 (ºC)	Pulse Sensor (BPM)	Defuzzy	Output/ Condition
Respondent #1	36.6	86.4	1	Sehat
Respondent #2	36.6	83.6	1	Sehat
Respondent #3	36.4	75.8	1	Sehat
Respondent #4	36.6	72.8	1	Sehat
Respondent #5	37.04	74.6	1	Sehat
Respondent #6	36.66	78.8	1	Sehat
Respondent #7	36.8	97.6	1	Sehat
Respondent #8	36.64	89.2	1	Sehat
Respondent #9	36.62	78	1	Sehat
Respondent #10	36.76	77.6	1	Sehat

Table 4. Algorithm Data Simulation

Simulation	MLX90614 (ºC)	Pulse Sensor (BPM)	Defuzzy	Output / Condition
Simulation #1	33.3	110	0	Sakit
Simulation #2	38.9	56	0,5	Kurang Sehat
Simulation #3	34.5	100	0,5	Kurang Sehat
Simulation #4	34.2	70	0,5	Kurang Sehat
Simulation #5	36.8	105	0,5	Kurang Sehat
Simulation #6	37.6	59	0,5	Kurang Sehat
Simulation #7	38.6	69	0.5	Kurang Sehat
Simulation #8	34.1	108	0	Sakit
Simulation #9	35.4	104	0	Sakit
Simulation #10	36.1	53	0.5	Kurang Sehat

CONCLUSION

The following conclusions can be drawn through a health monitoring system with a fuzzy algorithm. MLX90614 sensor (temperature), pulse sensor, HC-SR04 (distance), 5volt pump works well and runs according to its function. According to the results of testing that has been carried out, the monitoring system can determine whether the respondent is in a healthy, unhealthy or sick condition using a fuzzy algorithm. LCD displays the results of the respondent's condition output well. The fuzzy algorithm in this project goes through 3 stages to produce output. The first stage is fuzzyfication, determining limits in temperature and pulse membership which are divided into 3 categories, namely cold, normal, hot for temperature membership and slow, medium, fast for pulse membership. The second stage is to enter the fuzzyfication value in the predetermined rule. The third stage of defuzzification, the output value in the form of a fuzzy number will be returned to a real number followed by the membership output. Added a database and wifi module to store respondent data and send data in real time, as suggestions for further development.

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