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Design the Effectiveness of Various Temperature and Humidity Sensors for Outdor

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ABSTRACT

Effectiveness is a condition that shows the level of success or achievement of goals measured by quality, quantity, and time in accordance with what has been planned before. The temperature sensor measures the amount of hot / cold energy produced by the object so that it is possible to know or detect the symptoms of temperature changes in the form of analog or digital outputs. A humidity sensor is a measuring instrument to assist in the process of measuring or defining the humidity of water vapor contained in the air. This study used three categories of low price, standard, and expensive. The sensors used are temperature and humidity sensors, namely DHT11, DHT21, and DHT22 which are tested at three different times namely morning, afternoon, and night outdoors, as well as in extreme hot temperature conditions using irons and extreme cold temperature conditions using ice cubes inserted into containers. This study used a thermohygrometer as a comparison to determine the accuracy of the sensor. After taking data at three different times, namely morning, afternoon, and night outdoors and in extreme hot temperature conditions using irons and extreme cold conditions using ice cubes 30 times, the results obtained were DHT22 sensors with expensive categories whose effectiveness was better than DHT11 sensors and DHT21 sensors. Data from DHT11 morning difference in average temperature (T) = 0.70°C and humidity (H) = 20%, day 1.2°C and 10%, and night 0.70°C and 22%, as well as extreme heat 2.50°C and 4% and extreme cold temperatures average 0.50°C and 15%. The DHT21 sensor in the morning showed an average difference of 0.20°C and 12%, afternoon differences of 0.80°C and 15%, and night 0.30°C and 10%, as well as extreme heat of 0.90°C and 12% and extreme cold of 4.30°C and 4%. DHT22 sensor in morning difference of 0.10°C and 9%, afternoon 0.60°C and 15%, and night 0.10°C and 13%, as well as extreme heat 0.30°C and 12% and extreme cold temperature of 4°C and 2.50% compared to thermohygrometer.

1. Introduction

Effectiveness is a condition that shows the level of success or achievement of goals measured by quality, quantity, and time in accordance with what has been planned before. A temperature sensor is a component that can convert heat into electrical quantities so that it can detect symptoms of temperature changes in certain objects [1].

The temperature sensor measures the amount of hot / cold energy produced by the object so that it is possible to know or detect the symptoms of temperature changes in the form of analog or digital outputs. Temperature sensors are a family of transducers [2][3]. A humidity sensor is a measuring instrument to assist in the process of measuring or defining the humidity of water vapor contained in the air [4][5].

One type of humidity sensor is a capacitive humidity sensor. Capacitive sensors are electronic sensors that work based on the capacitive concept [6][7]. An outdoor temperature sensor is a sensor used to record air temperature data in a place. This kind of sensor designed to be weather resistant is usually associated with a solar radiation shield to prevent sunlight radiation that will affect temperature readings [8]-[10].

Based on the statement above, it can be said that the effectiveness of outdoor temperature and humidity sensors or outdoor or outdoor requires greater costs than sensors used indoors [11][12]. This is because sensors used outdoors are susceptible to damage due to natural factors and living things.

This study used three price categories, namely cheap, standard, and expensive. Of the three price categories including DHT11, DHT21, and DHT22 temperature sensors, it will be seen the influence of sensitivity obtained on the temperature and humidity of a place, whether the price of a more expensive sensor has a level of sensitivity to the temperature of a place or the same level of sensitivity at a low price and standard [13][14]. Sensor sensitivity testing uses extreme temperatures, ice cubes and fire or hot water as adjuvants. As a comparison of the sensitivity of the three sensor price categories, this study used a temperature and air humidity thermometer as a comparison.

2. Methods

2.1. Object of Research

This study used temperature and humidity sensors by comparing various sensors to determine the effectiveness of the sensors used. The types of temperature sensors and humidity sensors that will be used for this study are DHT11, DHT21, and DHT22.

2.1.1. DHT11

DHT11 sensor as Fig. 1 is one of the many types of sensors that are widely used for microcontroller-based electronics projects [15][16]. This sensor can detect air temperature (temperature) and air humidity (humidity). The size of the sensor is very small and practical making its placement anywhere. The price of the DHT 11 sensor is sold around only $ 1 or if it is rupiah to Rp. 15,000 so that this sensor is in great demand by electronics hobbyists, students, even for small-scale industries. Some of the specifications of DHT11 are described as follows:

1. Supply Voltage: 5 V
2. Temperature range: 0-50°C, error ±2°C, Humidity: 20-90%
3. RH: ± 5%
4. Interface: Digital

2.1.2. DHT21

The DHT21 digital temperature sensor is one of the most common sensors of the DHT temperature sensor range offering a relatively high temperature measurement accuracy of 0.50C in 0.10C steps with a relative humidity accuracy of +/- 3% [17]. The DHT21 sensor has only three wires, including power and ground, only one digital pin is required to be connected to the microcontroller. DHT21 sensor specifications:

1. Input voltage 3-5 V
2. 0.3 mA, idle 60µA
3. 2-second sampling period
4. Serial Data Output
5. Resolution 16-bit
6. Temperature: 0-50°C (accuracy: 2°C)
7. Humidity 20-90% (accuracy 5%)

2.1.3. DHT22

DHT22 sensors are commonly used as air temperature and humidity sensors. The DHT22 sensor is equipped with NTC (a type of thermistor) commonly used to measure temperature and has an 8-bit resolution that can be connected to a microcontroller [18]. DHT22 sensors require input voltages of 3.5–5.5 V. DHT22 or also known as AM2302 is a sensor that can measure air temperature and humidity somewhere [19][20]. This sensor is more accurate and precise in terms of measurement than DHT11, the disadvantage of DHT22 is that it is more expensive than DHT11. The DHT22/AM-2302 Technical Specifications as a whole can be described as follows:

1. Power supply range: 3.3–6 VDC (typical 5 VDC)
2. Current consumption at the time of measurement is between 1 to 1.5 mA
3. Output signal: digital over single bus with speed 5 ms/operation (MSB-first)
4. Detection element: polymer capacitor)
5. Sensor type: kapasitif (capacitive sensing)
6. Humidity sensing range: 0-100% RH (accuracy ±2% RH)
7. Temperature sensing range: -40 to +80°C (accuracy ±0.5°C)
8. Sensitivity resolution: 0.1%RH; 0.1°C
9. Repeatability: ±1% RH; ±0.2°C
10. Hysteresis humidity: ±0.3%RH
11. Long-term stability: ±0.5%RH/year
12. Average scanning period: 2 seconds
13. Dimensions: 25.1 x 15.1 x 7.7 mm

2.1.4. Liquid Crystal Display (LCD)

Liquid Crystal Display (LCD) is a type of screen display that uses liquid compounds that have a polar molecular structure, sandwiched between two transparent electrodes. LCD is usually used to display letters in the form of text, numbers or punctuation marks or certain symbols. LCD can be used to display 16 x 2 digits. This component has 16 usable pins. The following is the physical shape and pin I/O. LCD 16 x 2

2.1.5. Arduino Uno

The Arduino Uno is a circuit board based on the ATmega328 microcontroller. The IC (integrated circuit) has 14 digital inputs/outputs (6 outputs for PWM), 6 analog inputs, a 16 MHz ceramic crystal resonator, USB connection, adapter socket, ICSP header pins, and a reset button. This is what is needed to support microcontrollers easily connected with USB power cables or AC to DC adapter power supply cables or batteries [21][22]. Arduino hardware uses Atmel AVR as the processor, while software has a special programming language. Although Arduino uno uses ATMega microcontroller as the main platform, there are clone versions of Arduino developed by individuals or companies using other microcontrollers, but still compatible with Arduino in terms of hardware [23][24]. To ensure flexibility, programs are uploaded through the bootloader, there is an option to program the microcontroller directly through the ISP port [25][26]. The Arduino Uno differs from all early microcontroller boards in that it does not use a dedicated FTDI USB-to-serial driver chip [27][28]. In its place, the USB-to-serial implementation is the ATmega16U2 version R2 (the previous version ATmega8U2). Arduino Uno Rev.2 version featuring resistors to 8U2 to ground line which is easier to give to DFU mode [29][30].

2.1.6. Thermohygrometer

Thermohygrometer is an instrument that incorporates a device to measure air temperature and humidity, both indoors and outdoors. A thermohygrometer has 2 thermometers called a dry ball and a wet bulb. In use, dry tubers are conditioned in a dry state, while wet tubers are conditioned in a wet state by soaking in water. The principle of operation of the thermohygrometer depends on the cold evaporation event. Evaporation of water from the surface will bind heat, which leads to a decrease in temperature at the surface. As a result of this temperature drop, it will cause the wet bulb temperature to be lower than the dry bulb temperature. The value of air humidity is determined by the temperature difference in the dry bulb and wet bulb. The temperature range on the thermohygrometer is -40 °C to 70 °C with a humidity range from 20% RH to 90% RH. There are 2 types of hygrometers, analog and digital, which have differences in appearance. Analogously, using a pointed needle when you are in digital, temperature and humidity are displayed with clear numbers.

2.2. System Design

Fig. 1 is a block diagram showing the sensor flow as an outdoor temperature and humidity detection device using Arduino Uno as a microcontroller and displaying the output value via a 2x16 LCD.

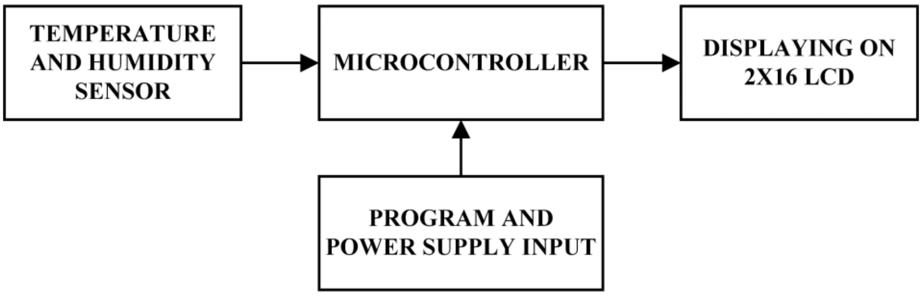

Fig. 1. Block diagram system

2.3. Flowchart

Figure 2 is a flowchart of the process starting from the program inserted into the Arduino followed by the temperature and humidity sensor, when there is nothing wrong with the program then the results will be displayed on the 2x16 LCD. The manufacture of hardware is followed by the wiring diagram of the components used. Wiring diagrams are connecting components using cables or PCB boards to connect between components. All components are connected to the Arduino UNO microcontroller. Wiring diagram of the tool using Arduino Uno as a microcontroller, temperature and humidity sensor connected to Arduino Uno and LCD 16x2 I2C to display the results of temperature and humidity sensor measurements.

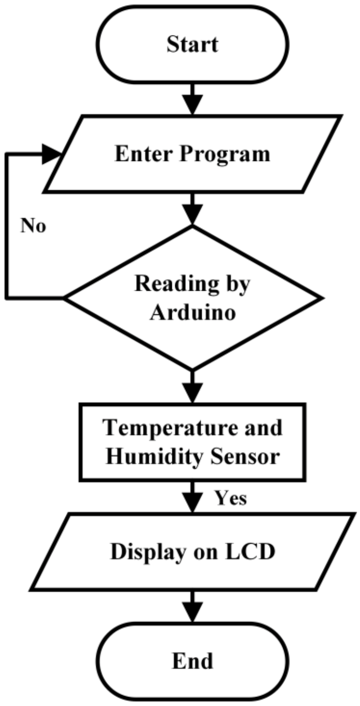

Fig. 2. Flowchart system

3. Results and Discussion

This sub section describes the results of the tool design using Solid Works software. The implementation of the tool in this study involves a transparent acrylic base with all the planned components and materials installed in sequence. The tool design reflects the physical representation of the previous concept, featuring clear visualization and the application of transparent acrylic material for a brightly lit structure. Fig. 4 illustrates the implementation details of the tool design, showing the systematic connection of each component, and meeting the specifications of this study.

3.1. Arduino Uno Testing

The program test in Fig. 3 is intended to check the Arduino UNO used in good condition connected to the Arduino IDE software, characterized by seeing the LED contained in the Arduino UNO flashing with a delay of 1 second.

Fig. 3. Program Arduino IDE

3.2. DHT11 Sensor Test Data

Data retrieval experiments using DHT11 sensors were conducted in the morning showing an average temperature difference of 0.70 °C and an average humidity of 20%, day showing an average temperature difference of 1.2 °C and an average humidity of 10%, and night showing an average temperature difference of 0.70 °C and an average humidity of 22% and at extreme heat showing an average temperature difference of 2.50 °C and 4% humidity and extreme cold temperatures showing an average temperature difference of 0.50 °C and 15% humidity with a thermohygrometer as a comparison.

3.3. DHT21 Sensor Test Data

Data retrieval experiments using the DHT21 sensor were carried out in the morning, afternoon, night, extreme heat, and extreme cold 30 times each as in the DHT11 sensor. Average temperature difference of 0.20 °C and average humidity of 12% for morning, afternoon with an average temperature difference of 0.80 °C and average humidity of 15%, and night of 0.30°C and average humidity of 10% and at extreme heat average temperature of 0.90 °C and average humidity of 12%, and extreme cold temperature average temperature of 4.30 °C and average humidity of 4% with thermohygrometer as comparison.

3.4. DHT22 Sensor Test Data

Data collection experiments using the DHT22 sensor conducted in the morning showed an average temperature difference of 0.10°C and an average humidity of 9%, the afternoon showed an average temperature difference of 0.60°C and an average humidity of 15%, and the night showed an average of 0.10°C and an average humidity of 13% and extreme heat shows an average of 0.30°C and average humidity of 12% and extreme cold shows an average of 4°C and average humidity of 2.50% with a thermohygrometer as a comparison. Based on the tests of the three sensors that have been carried out, the average difference can be seen in Table 1 and the average graph of the difference between sensors and thermohygrometers as shown in Fig. 4.

Table 1. Average difference between sensor and thermohygrometer

Sensor	Morning		Afternoon		Evening		Extreme Heat		Extreme Cold	
	T(°C)	H(°C)	T(°C)	H(°C)	T(°C)	H(°C)	T(°C)	H(°C)	T(°C)	H(°C)
DHT11	0.72	21.50	2.24	8.30	1.35	22.67	2.62	5.54	0.86	21.73
DHT21	0.28	12.60	0.76	13.27	0.36	13.05	0.11	14.45	3.48	0.31
DHT22	0.24	8.74	0.60	15.30	0.38	12.34	0.18	14.46	2.95	3.86

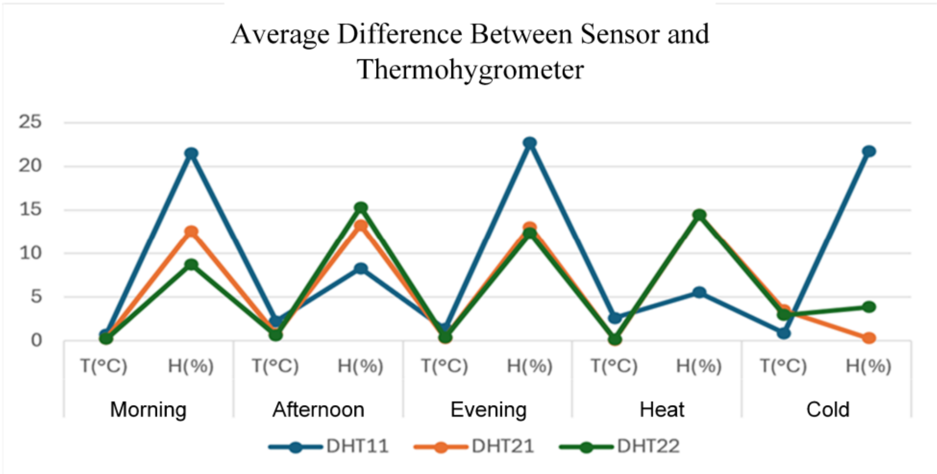

Fig. 4. Average difference between sensor and thermohygrometer

4. Conclusions

This series of air temperature and humidity control systems uses electronic devices including Arduino Uno, DHT 11 Sensor, DHT22 Sensor, Power Supply, and I2C LCD. This tool is made by assembling electronic devices into a system that can regulate temperature and measure air humidity outdoors and will display it automatically on the LCD. Based on the research that has been carried out, it can be concluded as follows: The research produced an outdoor temperature reader system that can be used to control temperature using a temperature sensor. The dht22 temperature sensor is a good temperature sensor and is suitable for room temperature monitoring from the three sensors used. The study has successfully tested at three different times of the morning, afternoon, and evening as well as extreme heat and extreme cold. Studies have successfully tested the effectiveness of temperature sensors and humidity sensors with 95% success. Taking into account the results obtained during the test and to improve them in the future, the following can be done: Pay attention to the placement of the sensor used in order to obtain an accurate value. The price of a sensor affects the effectiveness of a sensor. Pay attention to the placement of sensors to avoid damage or short circuit outdoors.

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