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Microcontroller-Based DHT11 Sensor for Temperature and Humidity Measurement

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Abstract

Technological developments for temperature and humidity measurement systems have experienced significant progress through the use of microcontroller-based sensors. This research aims to measure temperature and humidity using a microcontroller-based sensor. The sensor used is a DHT11 connected to a NodeMCU ESP8266 microcontroller as a data processing centre. The data collection process was carried out from 09:00 to 17:00 every 2-hour interval. Data from temperature and humidity measurements were at 09:00, the temperature was 30°C with a humidity of 73%, then when the temperature increased at 11:00 (32°C) and reached its peak at 13:00 (33°C), the humidity actually decreased to 67% and 62%. Furthermore, when the temperature began to decrease at 15:00 (31°C) and 17:00 (29°C), the humidity increased again to 70% and 75%. The higher the air temperature, the relative humidity tends to decrease, and vice versa. Microcontroller-based DHT11 sensor is an effective solution in environmental monitoring systems that require practicality and efficiency.

Keywords: DHT11 sensor, Humidity, Microcontroller, Temperature

1. Introduction

Monitoring temperature and humidity is a crucial aspect of maintaining environmental quality across the agricultural, healthcare, industrial, and everyday life sectors [1][2]. Air temperature impacts comfort, the metabolism of living organisms, and physical and chemical processes in the environment. Humidity, on the other hand, is closely related to water vapor content, which can impact plant growth, disease transmission, and air quality [3][4]. An imbalance in temperature and humidity can lead to various problems, such as decreased plant productivity, increased disease risk, and disruptions to food and pharmaceutical storage systems. Therefore, continuous and accurate monitoring of these two parameters is essential to maintain environmental stability and support informed decision-making [5][6].

Along with technological developments, temperature and humidity measurement systems have experienced significant progress through the use of microcontroller-based sensors [7][8]. This technology enables automated, real-time measurement processes, integrated with digital systems. Microcontrollers such as Arduino and NodeMCU can process data from sensors and transmit it to monitoring platforms, including those based on the Internet of Things (IoT) [9][10].

Several previous studies have developed air quality monitoring systems using the DHT11 sensor, as well as IoT-based temperature and humidity monitoring, but these have only been applied indoors [11][12]. Research comparing the measurement accuracy of the LM35 sensor and the DHT11 sensor for temperature monitoring has not yet been implemented for humidity measurement, and has not been implemented in an open environment [13].

Based on the description above, we will design a microcontroller-based DHT11 sensor that will be implemented in measuring temperature and humidity in an open environment. This sensor has several advantages, including ease of use, low cost, and the ability to provide temperature and humidity data in digital form, thus minimising reading errors. Therefore, the DHT11 sensor is an effective solution in environmental monitoring systems that require practicality and efficiency without sacrificing data reliability.

2. Methodology

This study uses a microcontroller-based sensor system to measure air temperature and humidity in environment. The sensor used is a DHT11 connected to a NodeMCU ESP8266 microcontroller as a data processing centre. The parameters measured in this study include temperature and relative air humidity. The data collection process was carried out from 09:00 to 17:00 every 2-hour interval by placing the sensor at the observation location, then the data read by the sensor was sent to the NodeMCU for processing and then displayed on the computer can be seen in the research flowchart, Figure 1.

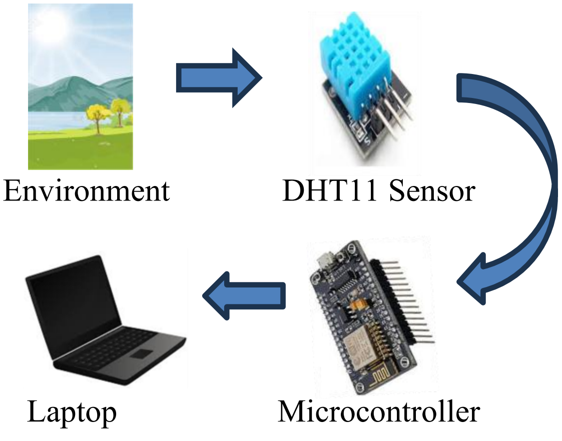

Figure 1. Flowchart of Microcontroller-Based DHT11 Sensor

The system's working principle begins when the DHT11 sensor detects temperature and humidity conditions in the surrounding environment using a thermistor sensor element for temperature and a capacitor for humidity. The analog data obtained is then converted into a digital signal by the DHT11's internal module. Next, the digital data is sent to the NodeMCU ESP8266 microcontroller via single-wire communication. The NodeMCU then processes the data according to the embedded program and sends the results to the computer to be displayed as monitoring data. Thus, this system is able to provide temperature and humidity information accurately, quickly, and efficiently for environmental monitoring purposes.

3. Results and Discussion

Testing of the microcontroller-based DHT11 sensor applied to air temperature and humidity measurements was conducted using a variation of measurement times from 09:00 to 17:00 every 2 hours. The results of the DHT11 sensor test for air temperature measurements can be seen in Figure 2.

Figure 2 shows the application of a microcontroller-based DHT11 sensor in temperature measurement, demonstrating the system's ability to monitor environmental temperature changes in real-time and with sufficient accuracy for daily monitoring. Based on the measurement results, the temperature at 09:00 was recorded at 30°C, then increased at 11:00 to 32°C, and reached a peak at 13:00 at 33°C. After that, the temperature began to decrease at 15:00 to 31°C, and decreased again at 17:00 to 29°C. This pattern indicates temperature fluctuations that follow a daily cycle.

The effect of temperature on time is clearly visible, with air temperatures tending to increase from morning to midday, then decreasing again in the afternoon [14]. This is due to the intensity of solar radiation increasing over time from morning until it peaks around midday, warming the Earth's surface and the surrounding air. After the peak solar radiation passes, the intensity of the radiation begins to decrease, resulting in a corresponding decrease in ambient temperature [15][16].

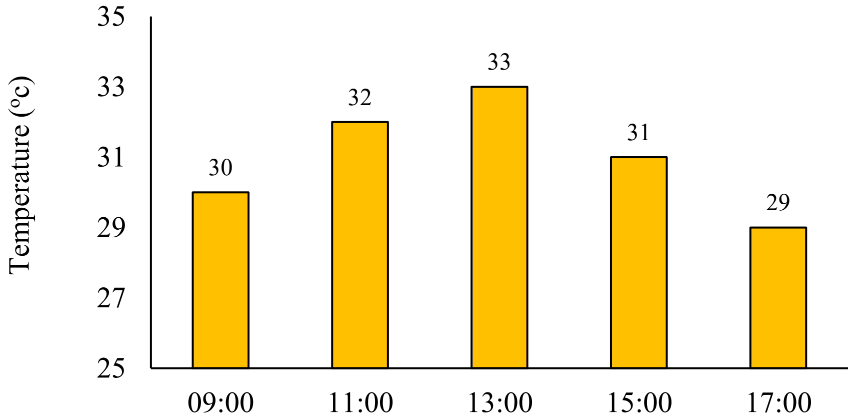

Figure 2. Temperature measurement against time using a DHT11 sensor

Additionally, other factors influencing temperature changes include weather conditions, air humidity, and environmental characteristics. Therefore, the use of a microcontroller-based DHT11 sensor is highly effective in describing daily temperature dynamics and can be utilized in various applications such as environmental monitoring, agriculture, and IoT-based systems. Next, the humidity measurement using a microcontroller-based DHT11 sensor is shown in Figure 3.

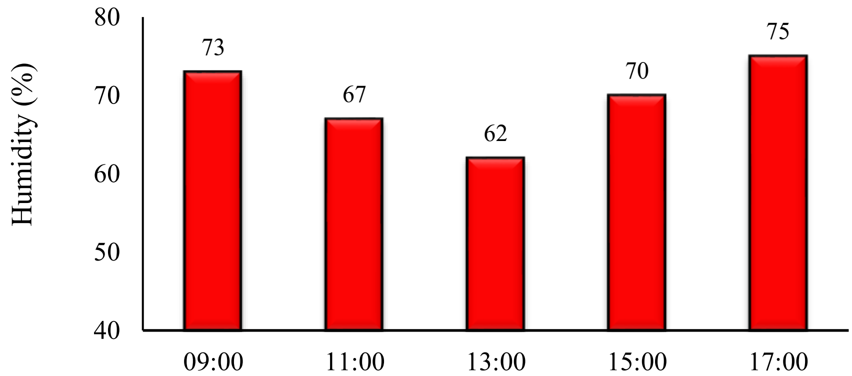

Figure 3. Humidity measurement against time using a DHT11 sensor

The application of a microcontroller-based DHT11 sensor in measuring air humidity, as shown in Figure 3, shows that the system can monitor changes in humidity levels continuously and in real time according to environmental conditions. Based on the measurement results, air humidity at 09:00 was recorded at 73%, then decreased at 11:00 to 67%, and reached its lowest value at 13:00 at 62%. Furthermore, humidity increased again at 15:00 to 70%, and reached 75% at 17:00. This pattern indicates a change in humidity that is inversely proportional to daily temperature.

The effect of humidity over time is evident in the tendency for air humidity to decrease from morning to midday, then increase again in the afternoon. This occurs because the air temperature increases during the day, increasing the air's capacity to hold water vapor, resulting in a lower relative humidity. Conversely, as the temperature begins to drop in the afternoon, the air's capacity to hold water vapor decreases, causing the relative humidity to rise again [17][18].

Furthermore, these humidity changes are also influenced by several other factors, such as solar radiation intensity, evaporation, wind movement, and environmental conditions such as the presence of vegetation and water sources. Therefore, the use of a microcontroller-based DHT11 sensor is highly effective in describing daily humidity dynamics and can be utilized in various fields, such as agriculture, weather monitoring, and IoT-based systems. The results of temperature and humidity measurements are in Table 1 and Figure 4.

Table 1. Temperature and Humidity Measurement using a DHT11 sensor

Time (Hours)	Temperature (ºC)	Humidity (%)
09:00	30	73
11:00	32	67
13:00	33	62
15:00	31	70
17:00	29	75

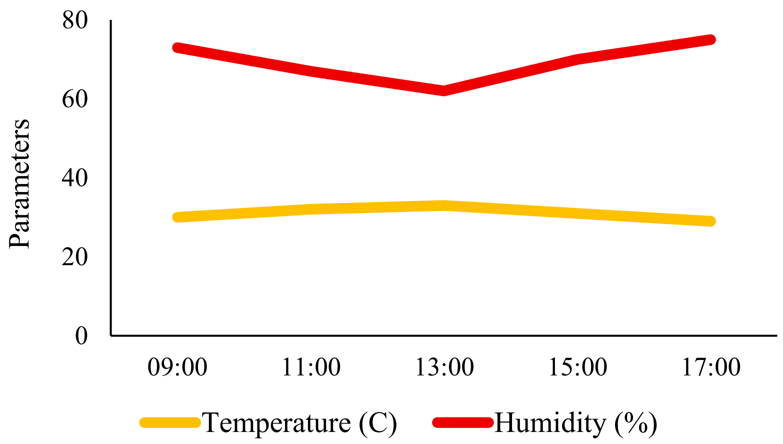

Figure 4. Effect of temperature and humidity on time

Based on the measurement data obtained using the microcontroller-based DHT11 sensor in Table 1 and Figure 4, an inverse relationship between temperature and humidity is seen. At 09:00, the temperature was 30°C with a humidity of 73%, then when the temperature increased at 11:00 (32°C) and reached its peak at 13:00 (33°C), the humidity actually decreased to 67% and 62%. Furthermore, when the temperature began to decrease at 15:00 (31°C) and 17:00 (29°C), the humidity increased again to 70% and 75%. This pattern shows that the higher the air temperature, the relative humidity tends to decrease, and vice versa [19][20].

This relationship is due to the fundamental nature of air's ability to hold water vapor. As temperature increases, air has a greater capacity to hold water vapor, so even though the actual amount of water vapor doesn't decrease significantly, relative humidity decreases. Conversely, as temperature decreases, the air's capacity to hold water vapor also decreases, so relative humidity increases.

Another contributing factor is the intensity of solar radiation, which influences the air heating process and the rate of evaporation. During the day, high solar radiation increases temperatures and accelerates water evaporation from land or water surfaces. However, because the air becomes looser in holding water vapor, relative humidity remains low. Meanwhile, in the afternoon, decreased solar intensity causes temperatures to drop and the air becomes more saturated with water vapor, increasing humidity. Environmental factors such as wind, cloud cover, and the presence

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of vegetation also influence the dynamics of the relationship between temperature and humidity.

4. Conclusion

Data from temperature and humidity measurements using a microcontroller-based DHT11 sensor shows an inverse relationship between temperature and humidity. At 09:00, the temperature was 30°C with a humidity of 73%, then when the temperature increased at 11:00 (32°C) and reached its peak at 13:00 (33°C), the humidity actually decreased to 67% and 62%. Furthermore, when the temperature began to decrease at 15:00 (31°C) and 17:00 (29°C), the humidity increased again to 70% and 75%. The higher the air temperature, the relative humidity tends to decrease, and vice versa.

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