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Design and build an IoT system for temperature and humidity observation using DHT 22 with ThingSpeak

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In a study conducted in recent years, it was found that atmospheric conditions such as temperature and humidity values greatly affect the climatic conditions of a region. This real-time temperature and humidity monitoring system is very useful and can be used in various regions. By using IoT, monitoring can be done in real-time. Temperature and humidity can use DHT 22 linked to ESP 32 and the data is stored and displayed in ThingSpeak. The trial of the monitoring tool was carried out for more than 31 hours and obtained 6920 data. At the time of the experiment the monitoring system worked well. At the time of observation for temperature the maximum value is 32.4℃, the minimum value is 28.1℃, the mean is 29.75621387283237℃, and the standard deviation is 3.587911994653761 and for humidity the maximum value is 81.4%, the minimum value is 63.6%, the mean is 72.6355404624 and the standard deviation is 3.5879112. From the experiment, it was also found that the temperature value was inversely proportional to the humidity and when it was going to rain the temperature value went up while the humidity went down and when it rained the temperature went up while the temperature went down.

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1. INTRODUCTION

The ongoing global warming has been clearly identified. The data says that the global average temperature has increased by 0.85 °C between 1880 and 2012. Not only that, the frequency of heat waves that reach the earth's surface increases on various continents. If no action is taken, it is estimated that the global average temperature will increase by 1.6 to 2.6 °C by 2050 with the European continent detailing 2℃ and the Americas 4℃. while on the Asian continent and Australia it is estimated to be higher [1].

Future climate predictions include an increase in temperature and a decrease in humidity on land, but these two factors remain constant in the oceans. This raises many questions as to why this can happen. Therefore, climate change prediction is very important because this will greatly affect life. In a study conducted in recent years, it was found that atmospheric conditions such as temperature and humidity values greatly affect the climatic conditions of a region. So the observation of these two components is important for the prediction model used. So that it can be used as an explanation for the conflict of differences in the influence of different climate changes on land and sea [2].

Temperature and humidity are one of the most important and interrelated elements. Not only for climate observation but also used in the industrial and factory worlds [3]. This can be exemplified in the food industry where temperature and humidity values are very important for the quality of the food produced [4]. In the industrial world, automation and smart infrastructure, real-time monitoring of temperature and humidity values is an important aspect [5]. This real-time monitoring system is very useful and can be used in various regions. This is very efficient because there is no need to come directly to the observation point. In

addition, it can also be applied to marine monitoring, room server monitoring, room temperature control and others [6].

For real-time and remote monitoring, sensors are needed to be connected to the internet. Temperature is often applied with IoT systems [7]. ESP32 merupakan salah satu mikrokontroler yang sangat populer dalam pengembangan sistem IoT karena memiliki Wi-Fi terintegrasi dan dukungan terhadap berbagai sensor lingkungan, seperti pada sistem pemantauan kualitas udara berbasis IoT yang mampu mendeteksi PM2.5, PM10, CO, NO_2, SO_2, dan O_3 secara real-time [8]. The sensor can be connected with a microcontroller to connect to the internet, software and network connectivity tools [8]. In addition, by using a microcontroller, various sensors can be added for better observation [9]. By adding other sensors integrated with IoT, the system can be more widely used in various fields such as agriculture, weather prediction, smart homes, banking, retail, and health [10]. Indicators that are usually added are sunlight and wind speed. All of these devices are also often integrated with IoT [11].

Some of the devices used for making Internet of Things (IOT) applications are Raspberry Pi and Arduino [12]. In addition, ESP is also often used in the creation of IoT applications. Because the price is cheap and does not require additional equipment because there is already Wi-fi available to transmit data read by the sensor [13]. The data from the sensor will be read by the microcontroller and sent to the computer or to the cloud via a Wi-Fi connection [14]. For IoT, many open source-based standard platforms can be used such as Cayenne, Blynk, ThinkSpeak, DeviceHive, Thinger.io, and so on [15]. Clouds like Thingspeak can also be used for visualization [16]. Using this standard platform, observations can be made at locations different from where measurements are carried out [17].

Temperature and humidity readings can be made using DHT 22 and DHT 11 sensors [18]. DHT22 is a sensor with a digital signal [3]. The DHT22 uses capacitive sensors and thermistors to detect temperature and humidity. The sensor operates on a Direct Current of 3.3–6 Volts and and has a measurement range of 0 - 100% for humidity as well as (-40°C) - 80°C. The difference in temperature and humidity values on the DHT22 sensor in the datasheet is 2%–5% for humidity and ±5°C for temperature [19].

2. RESEARCH METHOD

In this study, two stages are used in the design of the system, namely designing the hardware of the device and the network architecture of the device. To design a good tool must use good theory and start with the design of the tool [20]. And to find out the quality of the tool, the data obtained must be processed and analyzed

2.1. Designing and Building Hardware

The method in this experiment is to use a sensor connected to a microcontroller [21].

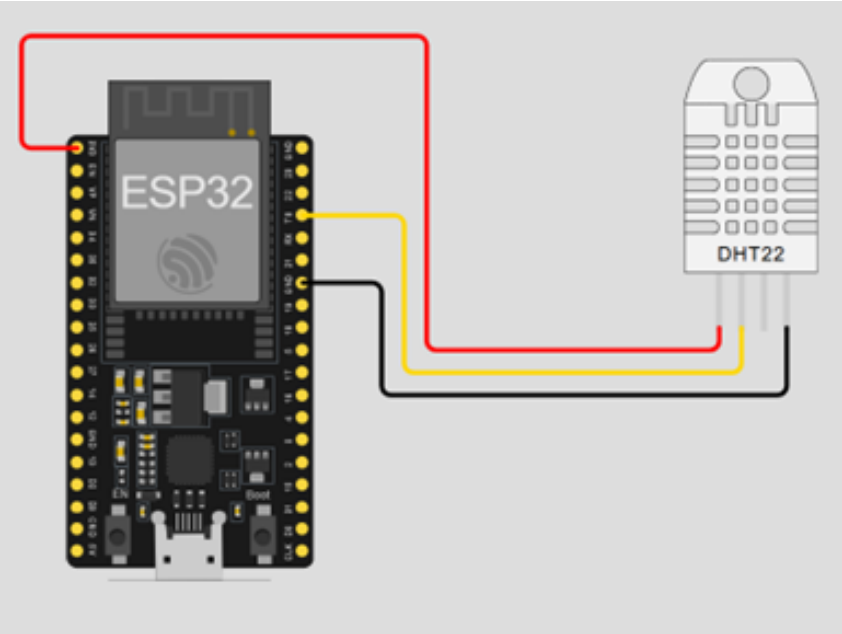

Fig. 1. Wiring Diagram

In this device, ESP must be connected to a voltage source that can be obtained from a laptop, Power Bank or charger. For starters, it must be connected to a laptop via a USB cable. This aims to send code from

the Arduino IDE software into ESP 32. After that, the VCC pin of the sensor is connected to the 3.3 V ESP32 pin, the sensor GND pin to the ESP32 GND, and the sensor data pin to the GPIO17 ESP32 pin.

2.2. Network Architecture

In this study, ThingSpeak is used which is a free web service to collect and store sensor data in the cloud and develop IoT applications. ThingSpeak is widely used in IoT applications [22]. In ThingSpeak, it will be set to display 2 results by creating 2 fields and named temperature and humidity.

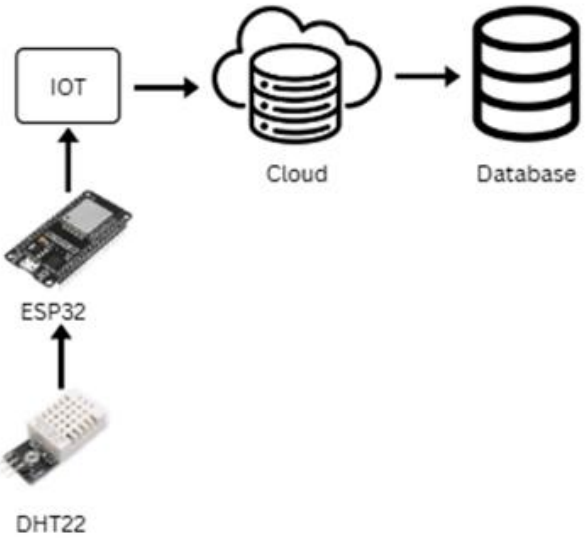

Fig. 2. System block diagram

In this system, the value measured by the DHT22 sensor will be sent to the ESP 32 where the ESP 32 that is already connected to Wi-Fi will send the data received by the sensor to the cloud and then stored in the database from ThingSpeak. With this mechanism, the measurement value from the sensor will be able to be observed from a distant place as long as the device is still in good condition and connected to electricity and Wi-Fi.

2.3. Data Collect

Data collection was carried out in the Tanah Tinggi area, Tangerang City. Data collection for device testing was carried out for approximately 31 hours. Measurement data will be stored in the database of ThingSpeak. Data will be sent to ThingSpeak every 15 seconds. The data will be downloaded in CSV format on the ThingSpeak platform.

2.4. Data Processing

After downloading the observation data, it will be processed using the Jupyter Notebook. The data to be calculated include maximum indigo, minimum value, mean, and standard deviation from the measurement results. Then the data found will also be displayed in the form of graphs to facilitate the analysis of the data. The formulas used include

Mean

$$\bar{x} = \sum_{i=1}^{n} x_i \qquad (1)$$

Standard deviation

$$\sigma = \sqrt{\frac{\sum_i^n (x_i - \bar{x})^2}{N-1}} \qquad (2)$$

3. RESULT

In its application the system with DHT 22 and ESP 32 is connected by jumpers according to the planned wiring.

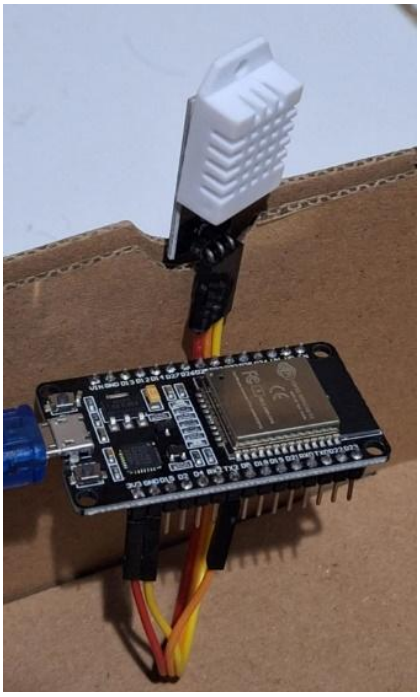

Fig. 3. Device Hardware Display

Here is a display from ThingSpeak that displays the temperature and humidity measurements from the sensor. The data is displayed in the form of a graph when temperature or humidity is relative to time.

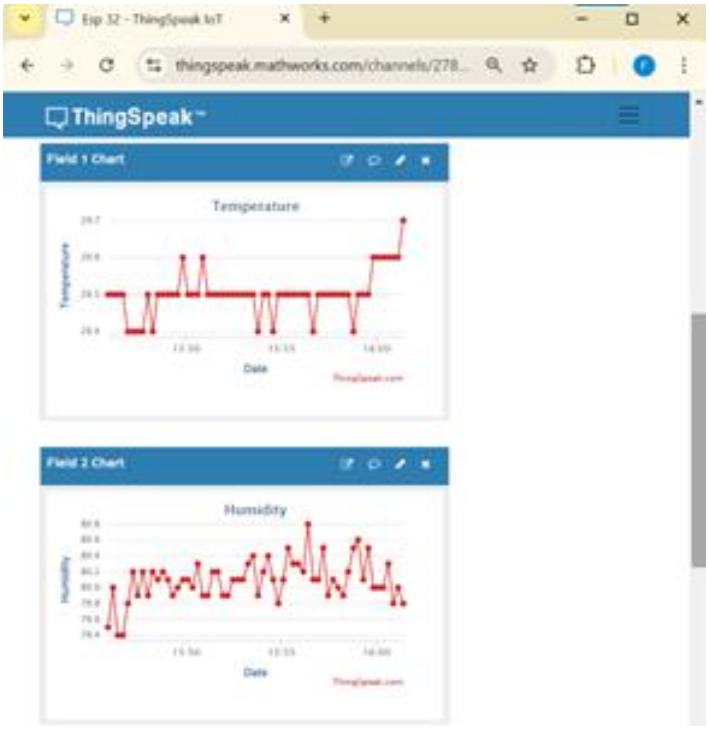

Fig. 4. ThingSpeak display

From the observation time carried out for more than 31 hours, 6920 temperature and humidity data were obtained. The following is shown some of the data in various conditions, namely the first time, during the day, when the weather is hot, when it is cold at night and when it rains.

Time	Temperature	Humidity
2024-12-14T08:44:39+07:00	29.8	74.4
2024-12-14T08:44:54+07:00	29.8	73.4
2024-12-14T08:45:10+07:00	29.8	73.4
2024-12-14T08:45:26+07:00	29.8	73.1
2024-12-14T08:45:41+07:00	29.8	73.6

Time	Temperature	Humidity
2024-12-14T12:14:38+07:00	32.1	66.2
2024-12-14T12:14:54+07:00	32.1	67.2
2024-12-14T12:15:09+07:00	32.1	67
2024-12-14T12:15:25+07:00	32.1	66.1
2024-12-14T12:15:41+07:00	32	66.3

Time	Temperature	Humidity
2024-12-15T03:07:12+07:00	28.6	73.5
2024-12-15T03:07:28+07:00	28.6	73.6
2024-12-15T03:07:44+07:00	28.6	73.7
2024-12-15T03:08:00+07:00	28.6	73.7
2024-12-15T03:08:15+07:00	28.6	73.6

Time	Temperature	Humidity
2024-12-15T15:56:40+07:00	29.4	80.1
2024-12-15T15:56:56+07:00	29.5	80.1
2024-12-15T15:57:12+07:00	29.5	80.5
2024-12-15T15:57:27+07:00	29.5	79.9
2024-12-15T15:57:43+07:00	29.5	80.1

Fig. 5. Some data from the observation results

The data obtained from the observation results are then calculated and observed. For temperature, the maximum value is 32.4℃, the minimum value is 28.1℃, the mean is 29.75621387283237℃, and the standard deviation is 3.587911994653761. For humidity, the maximum value is 81.4%, the minimum value is 63.6%, the mean is 72.6355404624 and the standard deviation is 3.5879112.

Here is a graph display of temperature and humidity values during observations made.

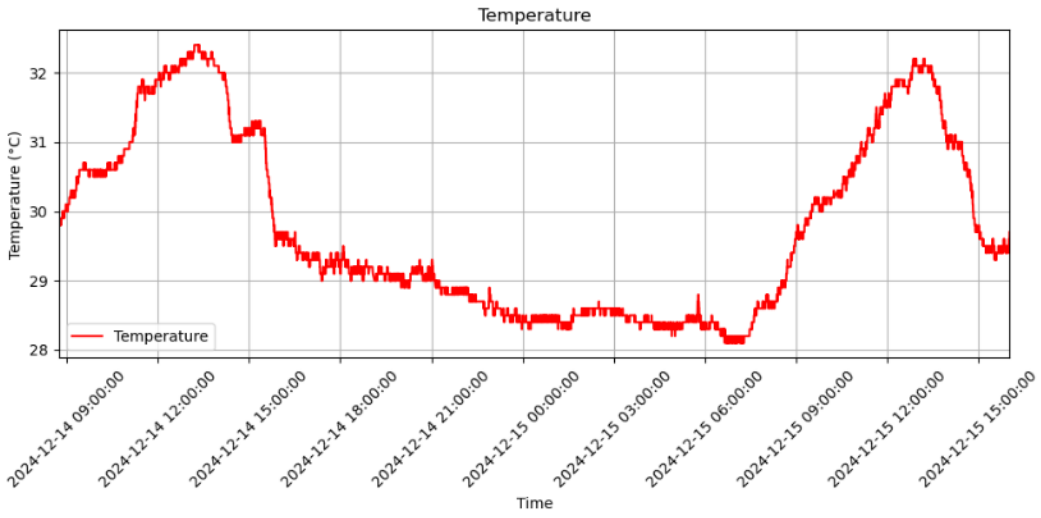

Fig. 6. Temperature graph during observation

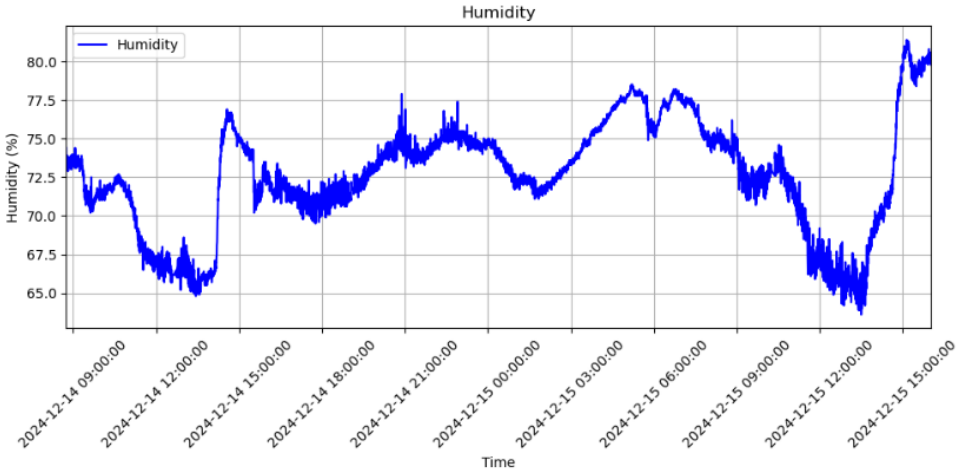

Fig. 7. Humidity graph during observation

4. DISCUSSION

From the hardware that was carried out during the observation experiment process with the system, there were no problems, which means that everything could run well. The ThingSpeak display is also easily accessible from a variety of devices and is easy to understand. These two things are important aspects in the observation process carried out. Observations were also made in various environmental conditions such as heat, cold and rain. This shows that this monitoring system can work well in all circumstances. The data obtained from ThingSpeak found that there was little data lost, this was due to a network connection that had been lost due to interference from the operator. And it can be seen that data is sometimes sent every 16 seconds, this is caused by several factors such as delays in reading and sending data, network connections, and from the specifications of sensors that take data about once every 2 seconds.

From the results of the calculation, it was found that the standard deviation from the temperature was 3.587911994653761 and the humidity was 3.5879112. This can be said to be quite large which proves the many variations in values that occur during observation. This is due to observations made in various environmental conditions, namely heat, cold and rain. Which conditions greatly affect the value of temperature and humidity. This is what causes a lot of variation in sensor data. But if it is in stable conditions such as at night, the data condition tends to be stable and this has a low standard deviation value. From this, it can be proven that this monitoring tool is good enough in measuring temperature and humidity values.

Based on the observation results that can be seen from the graph, a pattern of temperature and humidity values can be seen. The maximum temperature is 32.4°C and occurs during the day and drops to 28.1°C at night. Meanwhile, humidity tends to be lower during the day and increases when the temperature drops at night. However, on December 15, 2024, there was the highest peak in humidity, this was influenced because at that time there was rain, which of course increased the humidity value. The maximum value of humidity is 81.4 %, and the minimum value is 63.6 %. From the graph and environmental conditions, there are two things that can be observed, namely the value of temperature and humidity is inversely proportional, while when it rains the temperature increases and the humidity decreases and when it rains the temperature drops and the humidity rises.

5. CONCLUSION

From the results of the experiment conducted for 31 hours on December 14-15, 2024, the results were obtained that the monitoring tools made can run well and can operate in various environmental conditions. Some errors occur due to external factors, namely the network quality of the internet operator. The data that is displayed is easy to understand and access by anyone. At the time of observation for temperature the maximum value is 32.4℃, the minimum value is 28.1℃, the mean is 29.75621387283237℃, and the standard deviation is 3.587911994653761 and for humidity the maximum value is 81.4%, the minimum value is 63.6%, the mean is 72.6355404624 and the standard deviation is 3.5879112. The standard deviation value is quite high due to the environmental conditions that are quite diverse during observation. From the experiment, it was also found that the temperature value was inversely proportional to the humidity and when it was going to rain the temperature value went up while the humidity went down and when it rained the temperature went up while the temperature went down.

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