Development of embedded system in monitoring temperature and humidity as supporting smart farm

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Abstract. Enabling the environment is an important factor in developing livestock business. The temperature and humidity of the cage are very important aspects to consider. Inappropriate livestock cage temperature can affect livestock productivity and survival. The purpose of this research is to design a web-based temperature and humidity monitoring system, in the form of automatic regulation and measurement. In this research, embedded systems techniques are applied to build temperature monitoring systems by combining sensors and microcontrollers. Monitoring the temperature and humidity conditions of the enclosure is done through a sensor network and the classification of conditions is carried out by an intelligent system that produces web-based decision support. The sensor used to measure temperature and humidity in this monitoring system is the DHT22 sensor, while the controller is used NodeMCU. The results of this study are measurement data can be displayed on web pages that can be accessed in realtime. NodeMCU devices can be used as controllers for temperature and humidity data and successfully send data to a database that can be displayed on the website interface. Monitoring humidity and temperature is a great and easy way to record and track any changes which can help decision-makers to prepare or follow suit procedures to prevent conditions that can cause livestock.

1. Introduction

In the field of animal husbandry, many factors must be considered, generally in the management of the cage. Weather conditions are an important factor for the survival of livestock and its production processes, especially in the tropics region like Indonesia. One weather factor is temperature and humidity. Where conditions are too hot in the cage environment can trigger stress conditions in livestock. Stressful conditions can cause livestock to experience growth disturbance, decreasing production to lead to death [1]. High temperature and humidity of the cage is a vital sign that gives an indicates of stress conditions in farm animals. Assessment of vital factors can be used to monitor the temperature and humidity conditions of the cage so that it can help reduce growth disturbance in farm animals.
To be able to monitor the temperature and humidity of the cage is needed a tool that can give a sign that the cage is very uncomfortable for cattle. So there is immediate action from the cage owner. In this age of advanced technology, electronic technology has now reached the generation of the Internet of Things. Internet of Things (IoT) is a sophisticated technology that can be used to monitor and control hardware via the internet with good time efficiency and covers a large number of coverage areas [2]. The use of embedded device systems is also widely applied to the internet, one of which is the use of a microcontroller that replaces the old electronic circuits where generally the electronic circuits are complicated. By using IoT, every electronic device in the home and industry can be controlled and monitored, and can even be monitored remotely [3].

This study aims to design a telemetry measurement system in the form of temperature and humidity monitoring based on a web display. This monitoring system is expected to assist farmers in reducing the risk of death or decreasing livestock productivity due to the increase in ambient temperature. The method used in this experiment is an embedded-systems technique by combining sensors and microcontrollers (embedded controller). The telemetry system is an effort to obtain information on temperature and humidity conditions in livestock pens. The sensor used to measure temperature and humidity in this monitoring system is the DHT22 sensor, while the controller is used the NodeMCU Microcontroller.

The ESP8266 NodeMCU microcontroller was chosen as the controller unit because it has a small size and has a Wi-Fi chipset in it. While the selection of DHT22 sensors, because DHT22 is a sensor that has a good reading quality, is judged by the response of fast data readings and small size with relatively cheap prices [4]. Some studies on temperature and humidity measurements include the creation of a monitoring and control system of temperature and humidity on plant growth via GSM using a DHT22 sensor [5], design of a temperature and humidity with DHT22 and Arduino-based [6]; [7], Utilization of DHT22 sensors for monitoring temperature and humidity in glass crumbs [8], designing temperature and humidity gauges using Arduino-based DHT11 sensors [3], and measuring and monitoring soil moisture in agriculture by utilizing the Internet of Things (IoT) based on Android [9].

2. Methods
In general, the prototype design of a web-based temperature and humidity measurement system is explained through the following block diagram (Figure 1.). Some references in the design of temperature and humidity monitoring tools include: The Intelligent Agriculture System consists of sensors and systems system settings. The control system includes blowers, irrigation systems, and roof systems. This system helps farmers to make the right decision [10]. Some types of operating systems that can be used include Arduino [8], msp430 microcontroller [11], ATmega8 microcontroller with ZigBee transceiver [12], [13], STM32 NUCLEO platform [14].
This research method consists of 2 main parts, namely hardware systems and software systems. The main components used in hardware design are NodeMCU, DHT22 sensors, and several other electronic components. Hardware is a physical component used to form a series of electronic systems used to make the system consists of several main parts, namely the main circuit (mainboard), sensors and connectivity. Each of these components requires an interface as a communication channel between components. This hardware design is a NodeMCU module design. Below this is the instrument design scheme in the NodeMCU module (Figure 2.).

Figure 1. Block system diagram

Figure 2. Schematic of humidity and temperature measuring instrument
While in software design consists of several programs that function to control the hardware. Program modules created for hardware are a program module for automatic temperature control that uses a temperature sensor as an important input of the whole system as well as an interface program to display data through the web. The overall input and output initialization are done when designing software and hardware. The measured temperature and humidity data from the analog input are converted to digital using the DHT22 sensor. Then check whether there is an input client or server sari. The results of the temperature and humidity value process are displayed on a web page.

3. Results
In this research, testing has been carried out to check the performance of the hardware and software system (Figure 3). Figure 3 is the implementation phase of the main circuit or prototype hardware (Figure 4) test equipment on the server. Tests carried out focused on system accuracy and real-time monitoring of data for the development of efficient devices. This series of NodeMCU devices is used as a data reader or input that has been measured by the DHT22 sensor. Input data that have entered will be stored and encoded to transmit temperature and humidity data to the wifi network.

Based on table 1, it can be seen that the measured temperature and humidity from the server on the first measurement starting from 15.15 to 15.50. The next test is to display the results of temperature and humidity measurements that are monitored via the web. The next test is to display the results of temperature and humidity measurements that are monitored via the web. The process of sending data...
for temperature and humidity detection is initiated by the server which is then sent by firebase, after which the data received will be processed by source code. Following is the appearance of the web page as a result of the interface design implementation (Figure 5).

Table 1. Data of temperature and humidity measurements of prototypes

| Measurement duration (Minute) | Temperature (°C) | Humidity (%) |
|-------------------------------|------------------|--------------|
| 0                             | 23.8             | 48           |
| 3                             | 23.7             | 49.1         |
| 6                             | 23.2             | 49.6         |
| 9                             | 23.2             | 49.7         |
| 12                            | 23.3             | 49.6         |
| 15                            | 23.4             | 49.3         |
| 18                            | 23.3             | 49.1         |
| 21                            | 23.2             | 49.5         |
| 24                            | 23.3             | 50.1         |
| 27                            | 23.2             | 51.3         |
| 30                            | 23.3             | 51.7         |
| 33                            | 23.2             | 51.9         |

Figure 5. Display of temperature and humidity data via the Web

One of the developments of temperature and humidity measuring devices is that it has successfully developed a DHT22 sensor by using the ESP8266 NodeMCU Microcontroller which has a Wi-Fi chipset inside that can send data remotely via the Web and data storage using external memory. The renewal of the temperature and humidity measuring instruments has also been carried out to anticipate any negligence in monitoring the temperature and humidity in the cage by adding a sign or notification
that the temperature has been reached by the livestock comfort zone, which is above 28 C. The development of this measuring instrument can be accessed by everyone, for example, the owner of the cage and its employees. Another advantage gained from the development of this tool is the cost required is relatively inexpensive and is portable.

4. Conclusion
The prototype of the NodeMCU microcontroller-based temperature and humidity device was successfully implemented in a web-based application and could be monitored in real-time. NodeMCU devices can be used as controllers for temperature and humidity data and successfully send data to a database that can be displayed on the website interface. This device can be developed in the future by connecting to a fan or blower in a cage. So that when the cage exceeds the comfort zone, the microcontroller can immediately order the blower to cool the cage. Major developments in the field of information and communication technology in the field of monitoring and mitigation have added significant improvements to traditional techniques in terms of accuracy, precision, and faster data transfers so that they can save costs, time and energy.

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