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Research and application of IoT technology for food warehouse monitoring

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Abstract
The article presents research products on the application of IoT technology to monitor technical standards and environmental quality in food warehouses, supporting the storage of environmental data. The product also gives alerts and notifications via text messages and calls in a timely manner, thereby helping to improve the efficiency of food warehouse monitoring. The product serves the research and learning processes at the AD-AF Academy and is highly applicable in practical activities.

Keywords: Internet of Things -IoT, Food warehouses, Temperature, Humidity, Gas concentration

1. Introduction

Currently, a large part of food is being preserved in stockpiles. Warehouse supervision requires very strict technical assurance standards. Environmental specifications are always important factors affecting the quality of food preservation.

The 4th industrial revolution has brought great strides in all areas of life, creating a premise for new technologies to be applied in practice. Among the technological advances of the 4th industrial revolution must be mentioned the "Internet of Devices Network," also known as the "Internet of Things" (IoT). IoT systems allow sensing or remote control over existing network infrastructure, resulting in enhanced performance, reliability, and reduced human involvement [1, 3].

Therefore, the research and application of IoT technology to manufacture equipment that supports the monitoring of technical standards on temperature, humidity, gas concentration, etc. and gives warnings and notifications via informational messages and calls helps improve the efficiency of food warehouse monitoring.

IoT is a scenario of the world when each object and person is provided with its own identifier and all are able to transmit and exchange information and data over a single network without requiring direct human-to-human or human-to-computer interaction. IoT has evolved from the convergence of wireless technology, micromechanical technology, and the Internet. Simply put, a collection of devices capable of connecting to each other, to the Internet, and to the outside world to do a certain job [4, 7].

IoT is currently a growing trend in the world [8]. This technology is being applied in almost all fields. Some typical applications of IoT [9, 14]:

- Smart Home;
- Smart City;
- Smart Agriculture;
- Industry Internet of Things;

- In sports and health;
- In defense and security.

2. A food warehouse monitoring system using iot technology

Environmental management and monitoring in food warehouses are activities aimed at limiting environmental impacts and minimizing damage to food that is being stored and preserved in warehouses [15].

The current food warehouse environment is still largely monitored manually by warehouse management staff or has just stopped at the level of an automatic control system with close human participation. In the process of checking the parameters as well as the process of storing environmental data in the warehouse, it has to be done manually for each environmental parameter separately, which has not yet brought about high efficiency in monitoring environmental quality. environment in the warehouse, especially when managing warehouses with strict technical requirements [16, 17].

Therefore, it is required to have a system that both supports the ability to monitor environmental quality data, supports data storage, and supports remote management through alerts sent to warehouse management staff when environmental parameters exceed the allowable limit.

IoT technology allows automatic and continuous monitoring of environmental conditions in the warehouse through sensors and also supports the storage of those parameters. The use of this IoT system reduces inspection and supervision time as well as management personnel needs, improving efficiency in food warehouse management and monitoring. In case of any abnormal parameters, an alert will be immediately sent by the system to the manager for a quick and timely remedy to ensure the safety of the food warehouse.

3. System design and construction

Through studying the theoretical basis and design product requirements, the research team builds an overview diagram for the system consisting of 6 functional blocks, shown in Figure 1. In which, each block will ensure responsible for various tasks of information gathering, processing, and alerting.

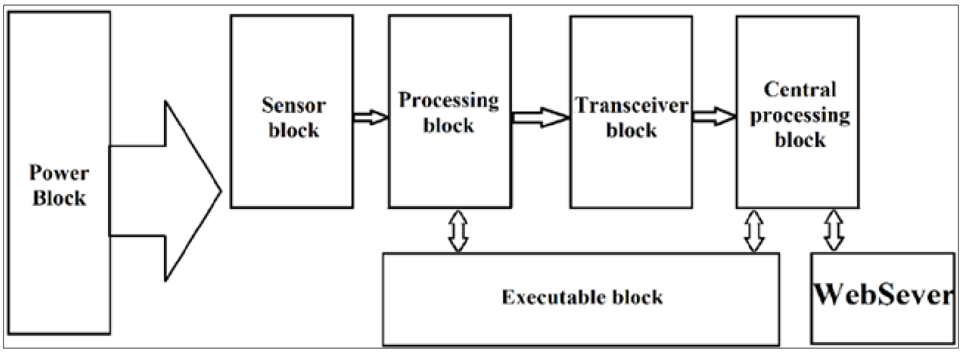

Fig 1: System block diagram

In there

The sensor block has the function of measuring temperature, humidity, and detecting fire and gas in the environment and bringing that information to the central processing unit for processing.

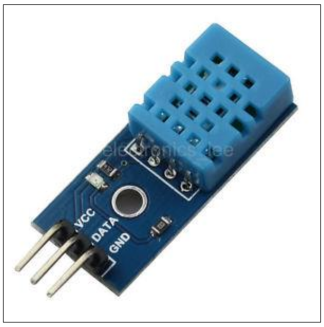

Fig 2: DHT11 temperature and humidity sensor

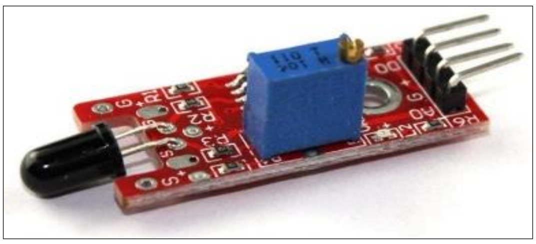

Fig 3: KY-026 Flame Sensor

Fig 4: MQ2 Gas Sensor Module

The processing block and the central processing unit have the function of controlling and receiving data from the sensor, thereby processing and deciding to control the transceiver module to transmit data.

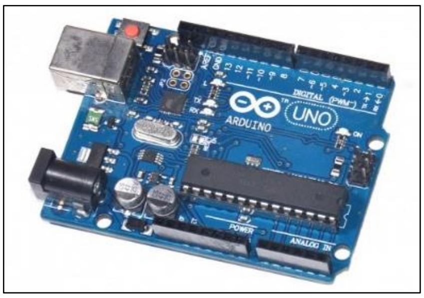

Fig 5: Central processing block using Arduino UNO R3

The transceiver block is responsible for transmitting data to the intermediate device.

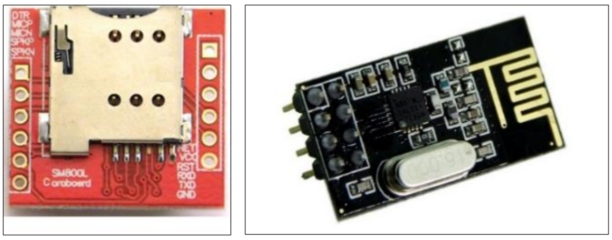

Fig 6: The transceiver block uses Module GSM GPRS Sim800L and Module NRF24L01

The execution block has the role of exporting the collected results of the sensors into data displayed on the screen and, in addition, giving warnings when there are abnormalities in environmental parameters.

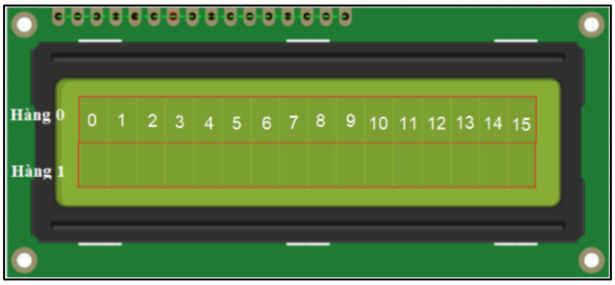

Fig 8: LCD display

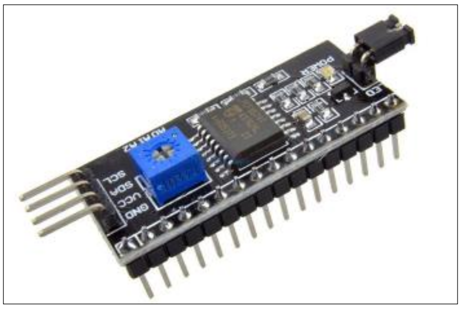

Fig 9: I2C conversion module for LCD

Fig 10: Buzzer

Fig 11: Relay module 2 channels 12V DC - 250 V AC model JQC-3FF-S-Z 12VDC

The power block has the function of supplying power to all active devices. Therefore, the power source must ensure enough power for the equipment.

Fig 12: Power block with LM2596 3A DC voltage reducing circuit

In order to monitor the environmental parameters of the food warehouse and generate warnings in various forms when a certain parameter violates the set threshold, the research team has built an algorithm diagram for the system. as shown in figure 13:

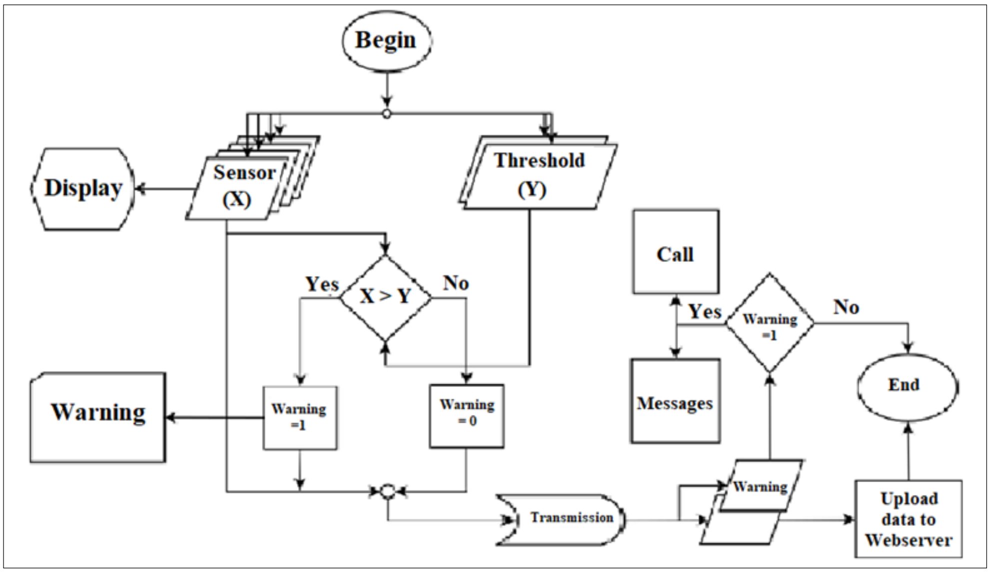

Fig 13: System Algorithm Flowchart

When starting to work, the sensors collect data of the environment. Each of these environmental parameters is set with a threshold level required by the food stock (this threshold level can be changed). Information about the parameter value along with its threshold level will be displayed on the LCD screen, and sent to the Web server through the transceiver, data transmission and display systems in real time. On the other hand, that information is also compared with threshold levels and gives warnings, if they violate threshold levels. These alerts are represented by whistles, making calls and sending messages to a predetermined subscriber. The warning will be continuously generated until the value of the environment parameter reaches the allowable value (problem fixed).

The product includes two devices: a transmitter and a receiver. The power source is converted from the 220V/50Hz grid through the adapter and the LM2596 3A DC voltage reducing circuit to supply the blocks.

The transmitter includes sensors that collect environmental data on temperature, humidity, gas, and fire to the central processing unit. Environmental parameters are also displayed on the LCD, along with predefined thresholds that are adjusted via knobs. The processing block in the transmitter compares the measured environmental data with the thresholds. If there are any abnormal readings, the system will have an audible alarm through the buzzer, and the data is transmitted to the receiver via the NRF24L01 module. The circuit board of the transmitter is shown in figure 14.

Fig 14: Transmitter

The receiver will receive environmental data from the transmitter via the NRF24L01 module, these data will be transmitted to the Web server by the ESP8266 module and displayed and updated on the Blynk interface is shown in figure 15.

Fig 15: Blynk interface

When one or more environmental parameters violate the threshold level, the receiver will warn with a buzzer. Simultaneously, the SIM800L module will make a call or send a message to a pre-set phone number. The receiver board is shown in Figure 16.

Fig 16: Receiver circuit board

4. Testing and evaluating product quality

The device is tested by measuring the temperature and humidity in the room at 5 different times a day and using the results to compare with the temperature and humidity measured by the hygrometer. The test results are as follows:

Table 1: DHT11 sensor evaluation test results

Temperature and humidity are measured by the DHT11 sensor	Temperature and humidity are measured by a hygrometer
Temperature 32,1oC, humidity 67%	Temperature 32,1oC, humidity 69%
Temperature 32,1oC, độ ẩm 68%	Temperature 32,1oC, humidity 68%
Temperature 31,7oC, độ ẩm 60%	Temperature 31,7oC, humidity 60%
Temperature 33,5oC, độ ẩm 57%	Temperature 33,6oC, humidity 56%
Temperature 34oC, độ ẩm 57%	Temperature 34oC, humidity 57%

According to the test results, the temperature and humidity sensors work well and are eligible to be used for environmental monitoring in food warehouses.To test the operation of the MQ2 gas sensor, we use some common gases, such as alcohol vapor, acetone vapor, insect spray, lighter gas, etc.

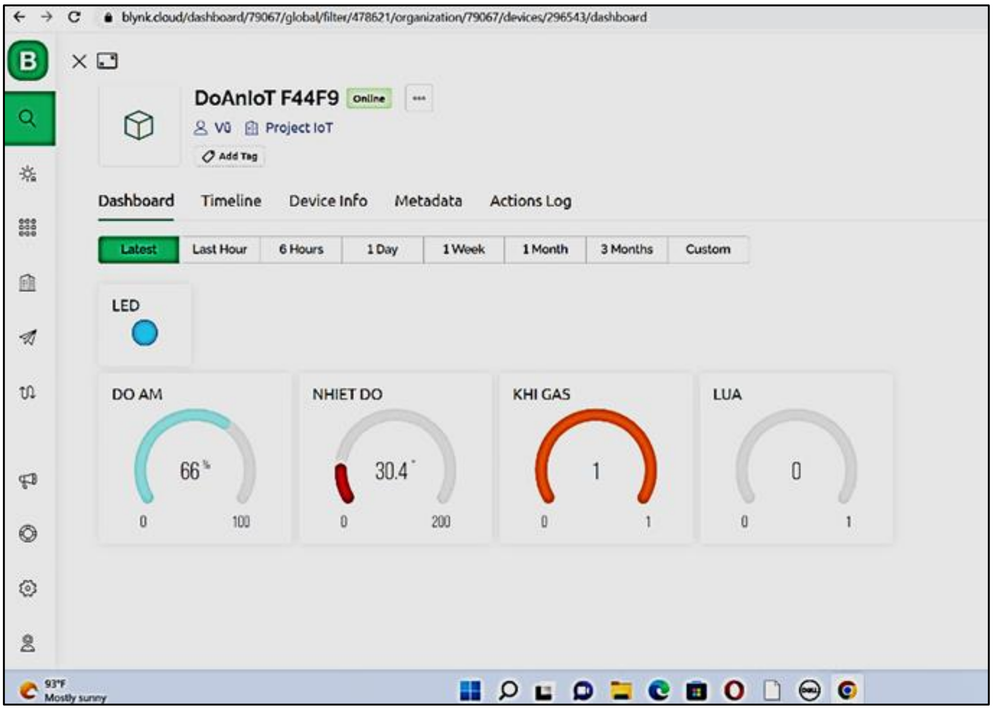

Fig 17: Gas test results shown on Blynk

Through testing, we found that the gas detection warning system works well with many different types of gas.Perform a fire detection sensor sensitivity test using fires at different distances. The results are shown in Figure 18.

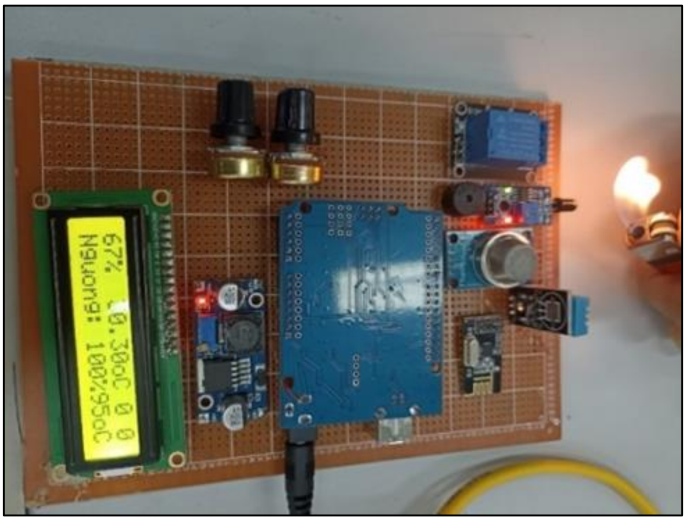

Fig 18: KY-026 sensor test

Through testing, the fire detection system works well at different distances and uploads the data to the Web server, generating an alert as shown in Figure 19.

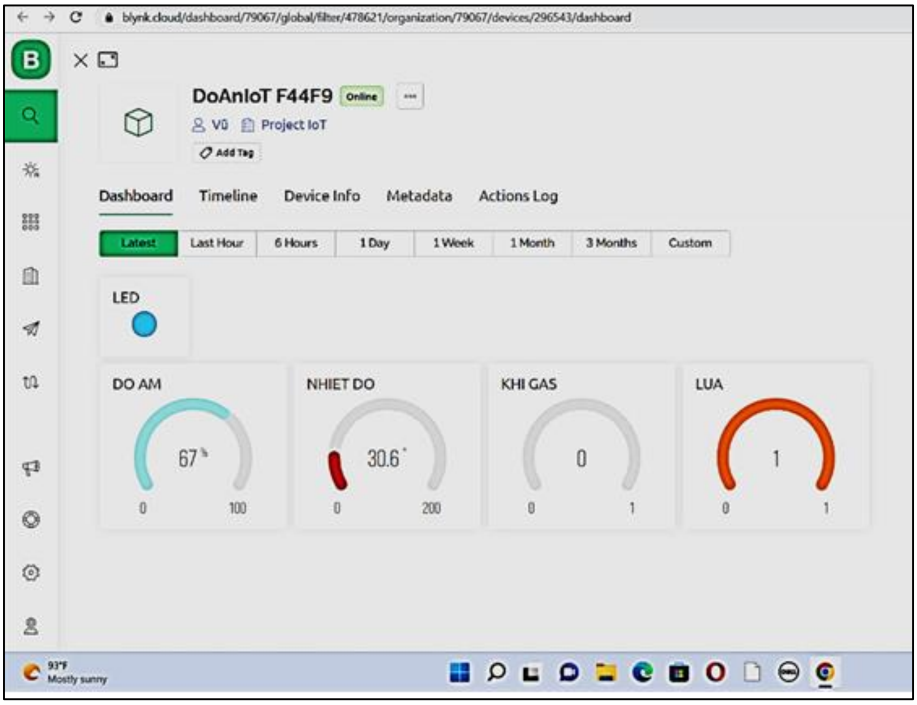

Fig 19: Fire detection test results displayed on Blynk

The results of testing the transceiver system by varying the distance between the two receivers and the transmitters are shown in Table 2.

Table 2: Test results of the transceiver system

Distance	Received signal
10m	Good
100m	Good
200m	Good
400m	Good

When a certain parameter exceeds the threshold, there will be an alert by calling and texting the pre-set phone number, as shown in Figure 20.

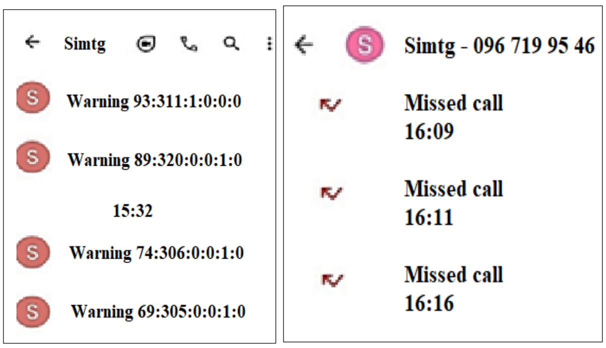

Fig 20: Alert calls and messages

5. Conclusion

The paper presents the research product "application of IoT technology in food warehouse monitoring." The product has high applicability in practical activities, with the following advantages:

+ Compact device with quick response time;
+ Simple operation, easy to use;
+ High-precision working equipment, safe for users;
+ Open design, we can add monitoring of other parameters by using more sensors. Besides, the system allows monitoring multiple warehouses simultaneously by cloning more transmitters;
+ The equipment works steadily and continuously, meeting all requirements. Besides, the system allows to change the standard threshold of environmental parameters.

The product is expected to develop more features in the future by integrating more sensor systems, developing its own control application, integrating voice control features, etc. to improve quality and operational efficiency.

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