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IoT-BASED TEMPERATURE AND HUMIDITY CONTROL IN A REFRIGERATOR USING ARDUINO UNO

M. K. I. Noraziz [1,a], E. M. M. Yusof [1, b*], N. Yahya [2, c*]

[1]Instrumentation and Control Engineering Section
Universiti Kuala Lumpur, Malaysian Institute of Industrial Technology (UniKL MITEC), 81750 Masai, Johor, Malaysia.

[2] Faculty of Computer Science and Mathematics
Universiti Teknologi MARA, Cawangan Perlis, Kampus Arau
02600 Arau, Perlis, Malaysia

[a]Khairulikhwan9719@gmail.com, [b]erniemazuin@unikl.edu.my,
[c]norzianayahya@uitm.edu.my

*Corresponding author's email : erniemazuin@unikl.edu.my

Abstract

One of the challenges in the cold agri-food chain industry is to check and control the temperature and humidity of the food storage to maintain the food quality. The need to have a food quality checking device is very much needed. There are attempts to supply systems or equipment for temperature and humidity control, but they are expensive and do not have effective integration of information needed together with the systems, such us between the equipment and various parameters. Therefore, this project discussed about a prototype that can be used to monitor and control the temperature and humidity parameters in a refrigerator. To achieve that, the prototype consists of hardware and software that are capable to connect to the internet and monitor the temperature and humidity readings, as well as regulating them. In this project, the hardware chosen were Arduino Uno microcontroller for data processing, ESP8266-01 module to connect the microcontroller to the internet, DHT11 sensor to detect the temperature and humidity of the refrigerator, 12 V-fan to regulate the parameters, 12 V-battery to power up the whole system and finally a website to show the data taken. The results indicated that the temperature and humidity can be controlled by the prototype through the fan when there is any change in the temperature. Ultimately, the cold food storage industry as well as household can benefit from the project whereby food spoilage and waste can be minimized.

Keywords: Cold food; Temperature; Humidity; Internet of Thing; Arduino Uno

1.0 INTRODUCTION

Background of the Study

The agri-food chain is confronting new challenges these days [1]. One of the challenges is to check and control the temperature and humidity of the food storage to maintain the food quality. Nevertheless, in the last three phases of the agri-food chain (transport, retail, and households), temperature, and humidity control and maintenance have become increasingly complicated in the initial phases of handling and distribution compliance with the temperatures and humidity established for food protection. In particular, the lack of available data on the cold food chain management is seen in the retail industry. There are also several reports which confirmed that the temperature and humidity of display cabinets in refrigeration systems are usually not appropriate, in accordance with safety standards.

In Europe, the EC Council and Parliament are proposing to designate food organizations to comply with temperature and humidity regulation standards and microbiological guidelines specific to food products, as well as cold chain management standards [2]. The rule builds up the importance of monitoring temperatures and humidity and bonafide operation of refrigeration equipment with regards to this last element, taking into account that regular temperature reading can be a significant strategy for managing the cold chain in retail establishments. However, studies have shown that this strategy is unable to ensure compliance with perishable food safety requirements, especially in southern Spain.

In order to prevent food waste, factors that cause the food to get spoiled and rotten should be observed [3]. The factors include temperature, and humidity or dryness. Especially in food stores, the need to have a food quality checking device is very much needed. The device is needed to perform an examination on the factors that cause the food to get rotten. Then, the variables can be controlled such as by refrigeration, vacuum storage and many others.

There are less research studies that called for temperature and humidity monitoring of cabinet and refrigeration equipment in the retail sector. Most of the scientific literatures that specialized in the retail sector emphasized on the calculation of the time period of food located in refrigerator equipment or whether or not it maintains the specified levels of temperature and humidity, while remaining far from a more in-depth analysis of the systems used for measuring and controlling temperature and humidity. Wireless sensor surveillance technologies, especially radio frequency (RF) and wireless sensor networks (WSN), are among the innovations offering temperature and humidity control solutions that are now accessible throughout the cold chain, with many works on its implementation to realize global traceability of food temperature at different points in the chain [4].

The Internet of Things (IoT) framework is becoming more relevant in order to provide solutions to address this problem, where sensors are linked to each other along the cold chain, transmitting valuable information for decision-making and preventing potentially unwanted occasions [5]. The IoT is therefore relied on to help retail chains control food standards, manner the end-of-life waste treatment, influence the temperature and humidity of freezers, refrigerators and warehouses, and contribute to minimizing the use of electricity.

There are companies specializing in refrigerator equipment which supply systems for temperature and humidity control, but the equipment has the drawback of being expensive and does not offer the prospect of going effectively to the information generated or incorporated into systems that track various types of parameters [6].

Therefore, the current project demonstrates a solution for the cold food chain for tracking and regulating temperature and humidity. Subsequently, the availability of all or any of the insights of the project including the developed prototype opens up the possibility for researchers and expert networks to correct and enhance aspects, extend functionality, substitute components, or compare modes of operation. The specific objective of the project is to monitor and control the temperature and humidity in a refrigerator using Arduino Uno and IoT.

2.0 EXPERIMENTAL

Project Methodology

In order to achieve the objective of this project, the methodology to conduct this project is outlined. The parameters to be calculated and controlled in this project are the temperature and humidity within the refrigerator. The microcontroller of the project is the Arduino Uno. Other hardware include DHT11 sensor, ESP8266-01 module, relay, 12 V-battery, 12 V-fan and refrigerator. The flowchart of this project is shown in Fig. 1.

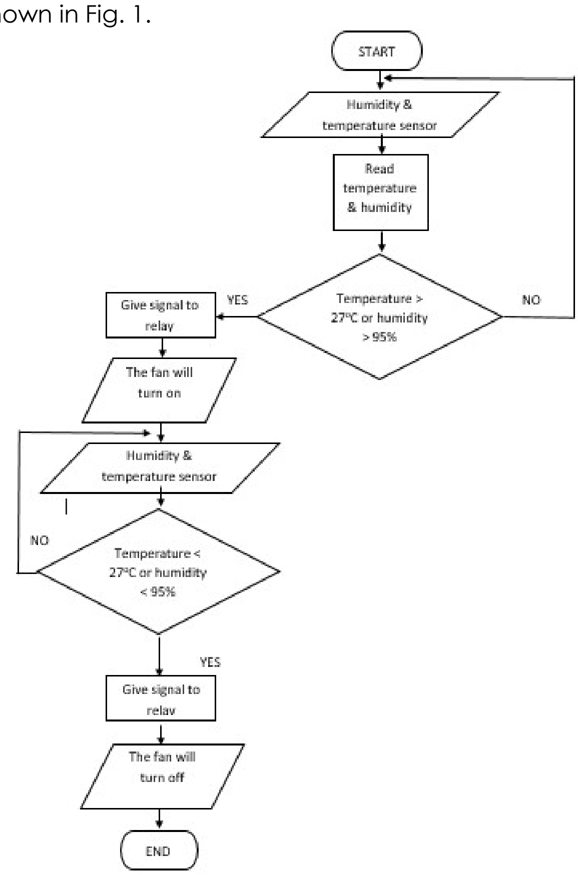

Fig.1: Flowchart of the Project

Schematic Diagram

The schematic diagram shows all the components of electrical connections. The schematic diagram for the project is done using the Fritzing software. This project is using an Arduino Uno, DHT11 sensor, ESP8266-01 module and 12 V-battery. Fig. 2 displays the schematic diagram of the project.

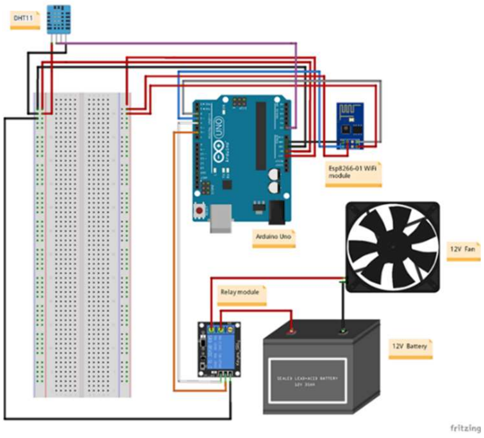

Fig. 2: Schematic Diagram of the project.

Based on the schematic diagram, the input for this project starts with the DHT11 sensor. The DHT11 sensor will read the temperature and humidity inside the refrigerator. The Arduino Uno will send the input data to the output which is the 12 V-fan and it will display the output through the ThingSpeak platform.

Hardware and Software Used for the Project

This section describes the hardware and software used for the project. Arduino Uno, ESP8266-01 Wi-Fi module, DHT11 sensor, relay, 12 V-fan and 12 V-battery and relay are the hardware used to construct the prototype of this project. They are shown in Fig. 3, Fig. 4 and Fig. 5 respectively. Meanwhile, Arduino IDE and ThingSpeak are used as the software for this project, as shown in Fig. 6 and Fig. 7 respectively.

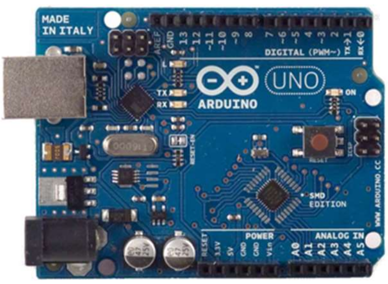

Fig. 3: Arduino Uno Board

Fig. 4: ESP8266-01 Wi-Fi Module

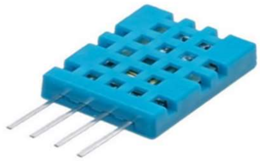

Fig. 5: DHT11 Sensor

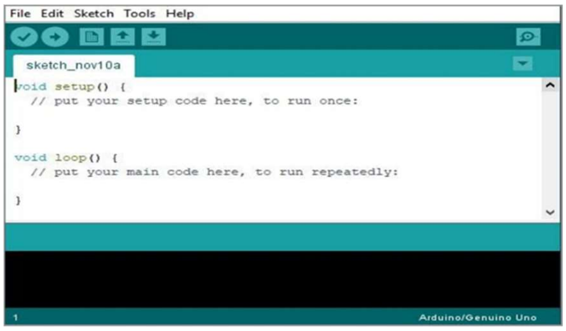

Fig. 6: Arduino IDE Interface

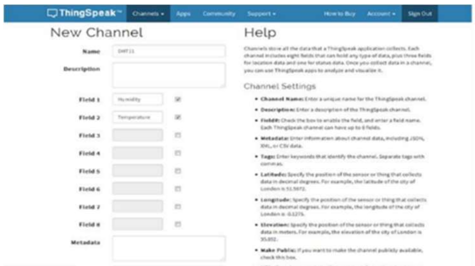

Fig. 7: ThingSpeak Software

3.0 RESULTS AND DISCUSSION

The Prototype

Fig. 8 shows the prototype developed for this project. The DHT11 sensor was mounted inside the refrigerator together with other components which are Arduino Uno, Esp8266-01 module, breadboard and relay. The 12 V-battery was also mounted as the power source. Meanwhile, the 12 V-fan was mounted at the back of the prototype as shown in Fig. 9.

Fig. 8: Prototype of the Project

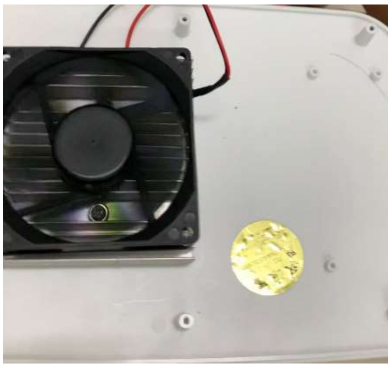

Fig. 9: 12 V-Fan Located at the Back of the Prototype

Data Analysis

Table 3.1 shows the result obtained by observing the relay and fan resulting from the temperature change. The set point for the temperature is 20 °C. For case 1, the temperature detected was 30 °C. Thus, the relay and fan were turned ON. For case 2, the relay and fan were turned ON since the temperature detected was 25 °C. Finally, when the temperature reading was 19 °C, the relay and fan were turned OFF.

Table 1: Results from Temperature Change

Case	Temperature Reading	Relay	Fan
1	30°C	ON	ON
2	25°C	ON	ON
3	19°C	OFF	OFF

Fig. 10 and Fig. 11 further show the graphs resulting from the monitoring of the temperature and humidity readings inside the refrigerator. As shown in Fig. 10, when the temperature value was lower than 20 °C and the humidity value was lower than 95%, the fan turned OFF. Conversely, in Fig. 11, when the temperature value was higher than 20 °C and the humidity value was higher than 95%, the fan turned ON.

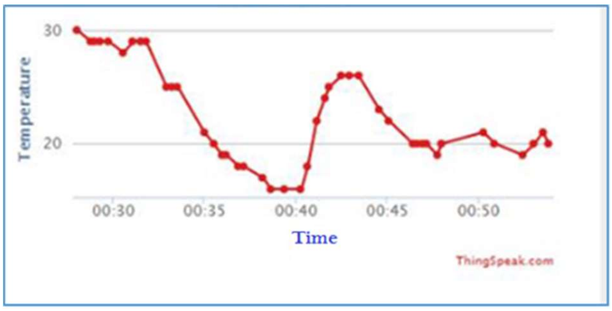

Fig. 10: Temperature vs Time

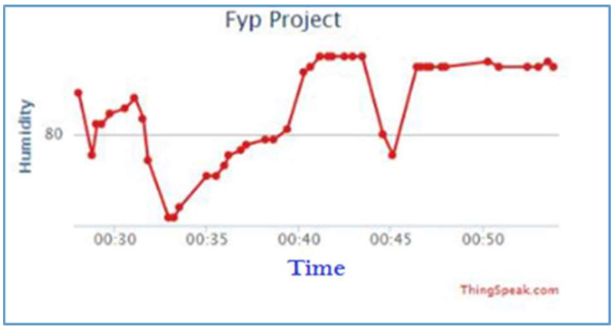

Fig. 11: Humidity vs Time

Discussion

We may deduce from this prototype that temperature and humidity are closely regulated, subsequently resulted to the reduced chance of food spoiling. Since the hardware utilized has the threshold temperature below the refrigerator's temperature level, the prototype may function successfully at cold temperature in the refrigerator. The prototype may also be connected to any refrigerator. This prototype may be deployed at homes, restaurants, and other businesses.

4.0 CONCLUSION

The project has achieved its objective whereby a prototype of IOT-based temperature and humidity monitoring and control in a refrigerator using Arduino Uno is successfully developed. The test is completed, and a dependable output is obtained, with all hardware functioned. The results indicated that the temperature and humidity can be controlled by the prototype through the fan when there is any change in the temperature. The IoT is causing a revolution in the world of electronics since it addresses numerous difficulties in daily needs.

There are few recommendations to be considered for improvement of the current project. It is suggested to use heat-sensitive materials at the cold side of the refrigerator and heat resistive materials at the hot side of the refrigerator to ensure the optimization of the cooling process. Other than that, a smart kitchen or a smart refrigerator project can also be realized by combining the ideas of IoT with cloud storage.

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