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DEVELOPMENT AND IMPLEMENTATION OF A LOW-COST IOT SYSTEM FOR SMALL FARM HOUSEHOLDS

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ABSTRACT

This study presented the design and the implement of a low-cost IoT system in order to monitoring and controlling the greenhouse environment for small farm households. The IoT system involved the interconnection between the hardware components and the software to allow for full remote and autonomous control of small greenhouses. Parameters monitored by a mobile application include: air temperature, air humidity, soil moisture and light intensity. Ventilation and temperature are optimized by controlling the roof-hatch with a linear actuator and control of a mist pump and a ventilation pump. The irrigation is controlled by a solenoid valve based on the soil humidity signal. The light intensity sensor is used for controlling LED grow lights that support lighting for plants. The resulting prototype demonstrate an accurate and reliable operating system. This system can be installed in new and existing a household farm. Further development could be focus on a program optimization for different crops, additional components and functionalities.

Keywords: IOT System, Small Farm, Datalogger, Greenhouse, Android Application.

I. INTRODUCTION

The small farm households play an important role in agricultural production, especially in less-developed countries and developing countries. They produce 70–80% of the world's food [1]. Despite their contribution to food production, many of these smallholders are applying outdated technology. Thus, the yield and quality of agricultural products are reduced. Therefore, the application of modern technology in production for smallholders is an urgent requirement.

In recent years, the Internet of Things (IoT) technology has been widely applied in agricultural production. However, this technology is usually only applied to large-scale farms with high investment costs [2, 3]. Hence, the application of IoT technology for small farms is still limited. Besides, there are some studies for applying IoT technology for indoor planters [4, 5].

Agricultural production is highly dependent on weather and climate. For example, changes in temperature and soil moisture can lead to reduced crop yields. Therefore, continuous monitoring of ambient factors such as air temperature and humidity, soil temperature and humidity, solar radiation, etc. is essential. IoT platform can be used to monitoring and controlling these parameters to improve agricultural techniques, increase yield and quality of agricultural products while reducing production costs and preventing waste of irrigation water and fertilizers [6].

This project presents the design and implement of low-cost IoT system for small farm households that automatically monitors and controls the main variables related to the plant's growth. The system is designed with the following requirements: low cost, accessible to small farmers and easy to use.

II. METHODOLOGY

A - System Block Diagram Design

The schematic diagram of a low-cost IoT system is showed in Figure 1. Functions of each block are described as follow:

Microcontroller Module: Control the operation of the system by receiving the value from the sensor, and control the power output module.

Sensors Module: Measure value of air temperature, air humidity, soil moisture and send it to the Microprocessor Module in real time.

Power Output Module: Close or open relay based on the control signal from Microprocessor ATmega328P. To avoid the noise from coil, the isolation circuit was used between power and control module.

Wifi Module: Send and receive data from Firebase's Realtime Database. The data was saved at Firebase console

Control and Display Module from Internet: Control equipment, display sensor values, and set up control parameters for fully automatically program or control ON/OFF devices by using manual control selection.

B – Microcontrollers

In this project, IoT system of small greenhouse was developed based on ESP8266 and Atmega328P microcontroller. These microcontrollers were chosen because it used in common and low cost but fully functions for many applications. In addition, it could easy communicate with other devices such as computers, phones and network.

C – **Sensors and Actuators**

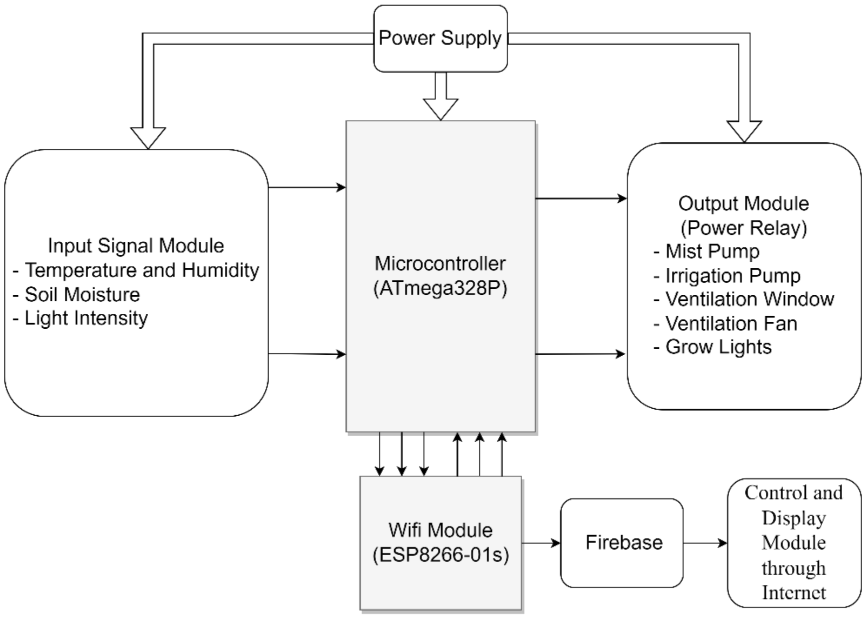

Figure 1: The overall of an IoT system

The sensors used on this project is given in Figure 2.

a) DHT11 Air temperature and Humidity sensor
b) SN-M114 soil moisture sensor
c) BH1750 Light intensity sensor

Figure 2: The sensors used in IoT system in this study

And, the most widespread devices implemented on this project are fans for ventilating and cooling, electric cylinder for opening ventilation window, lamps for enhancing plant growth, mist pump for humidity modification, and water pump with electromechanically operated valves for irrigation. These actuators are showed in Figure 3.

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a) Fans for ventilating and cooling

b) Drip irrigation pump

c) Grow LED

d) Mist pump for humidity modification

e) Electric cylinder

Figure 3: The actuators used in this study

III. SYSTEM IMPLEMENTATION

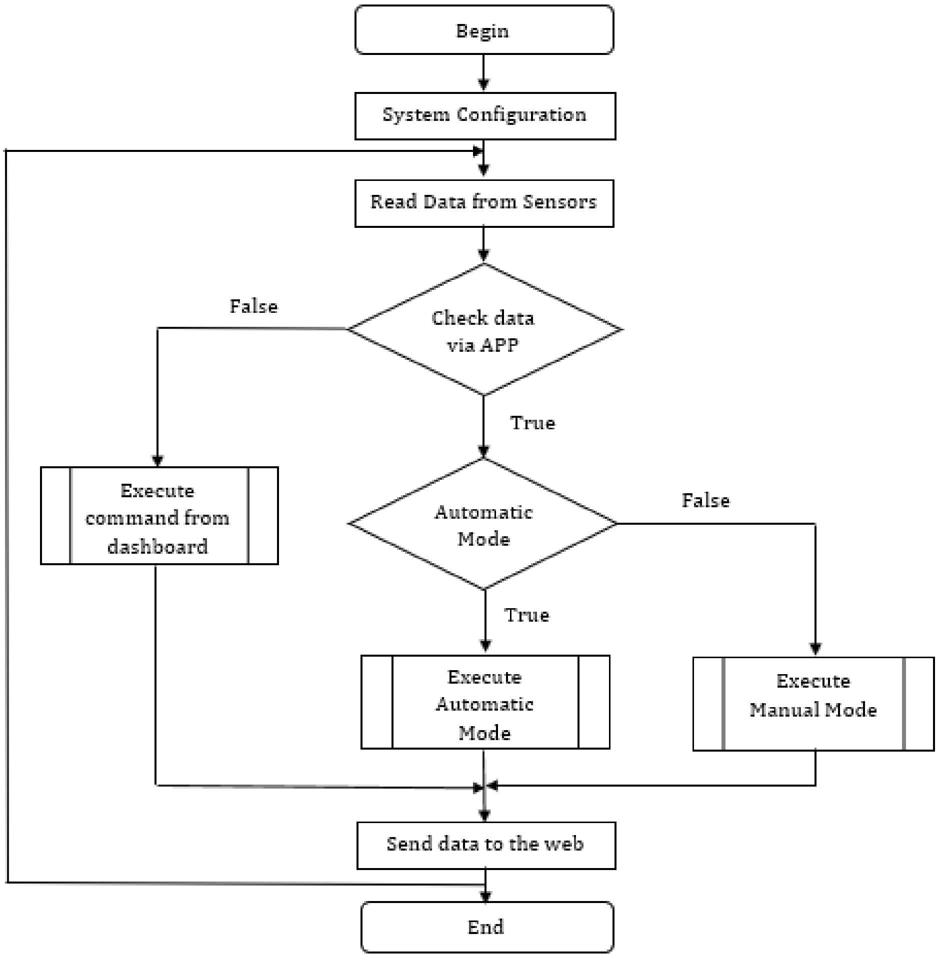

Figure 4: Flow chart of small farm monitoring and control system

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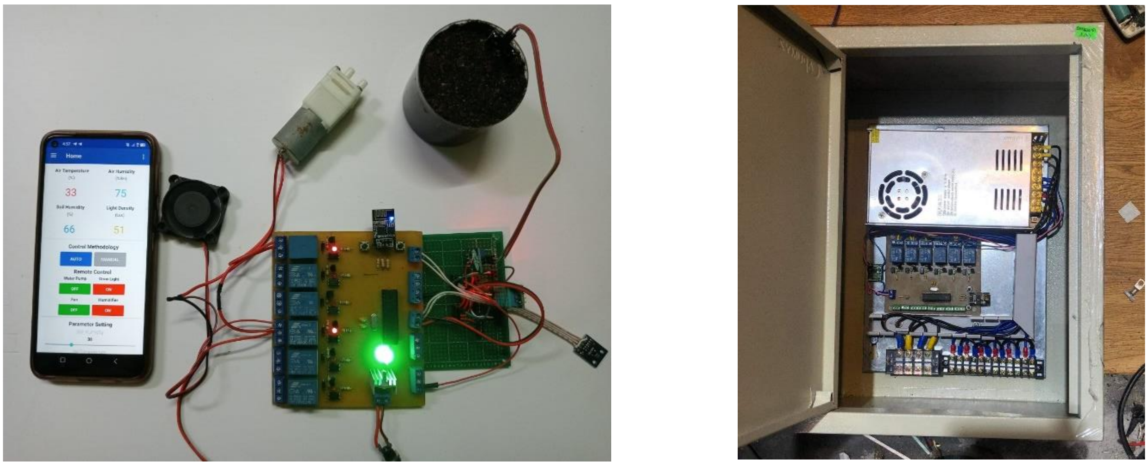
For implementing the IoT system, the sensors which are input devices and the actuators which are output devices were all connected to the microcontroller in order to real-time monitoring and controlling the environment and the irrigation of the greenhouse through the wireless connection. The flow chart of greenhouse monitoring and control system is showed detail in Figure 4.

The program starts the ESP8266, and initializes the sensors. If the program is not connected, it will wait until there is a connection then execute loops. The program that will check the data from the smartphone application in order to execute automatic mode or manual mode. If the system is in automatic mode, it will execute the program according to the pre-set parameters. Opposite, it will execute according to the user's actions on the app or on the dashboard. The data is then sent and stored on the website.

IV. RESULTS AND DISCUSSION

The low-cost IoT system was designed and implemented successfully in this study. The initial operation of the circuit was performed for adjusting parameters as required. After the calibration is complete, the circuit is inserted into the control box to connect the test model. These processes were shown in the figure 5. The initial test indicated that though each individual component worked well in a stand-alone in the system, there were inconsistencies observed in the integrated systems.



a) Initial test operation b) The control box after installation

Figure 5: The low-cost IoT system for small farm

The experiments were implemented in a greenhouse model with dimensions 1.2x1.2x1.5m. It was shown in Figure 6. The test results showed that the temperature inside greenhouse always maintain below 30^{0}C and keep the air humidity at 70% to 85%. In addition, the soil moisture also sustains in the range of 60 to 70% and the light intensity is always kept between 500 and 650 Lux. These results are suitable for many types of crops to grow [7]. Figure 7 showed the detail of the experiment results in this study.

Figure 6: The greenhouse test model

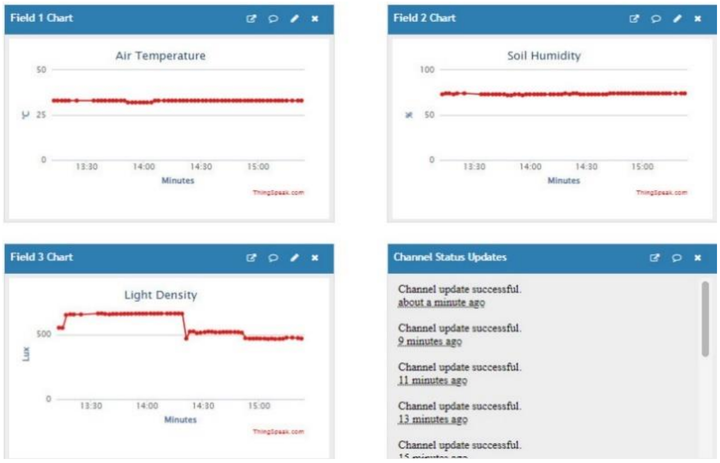


Figure 7: Some measurement results in this project

In addition, users can monitor the environmental information and control actuators remotely by smartphone via 4G/Wi-fi connection. The mobile application can be installed on Android platforms with a friendly interface to easy-to-use. Besides, it has real-time hardware communication, and is highly reliable. The mobile application interface for the user is illustrated in Figure 8. The data from sensors stored at Thingspeak and are updated automatically every 2 minutes.

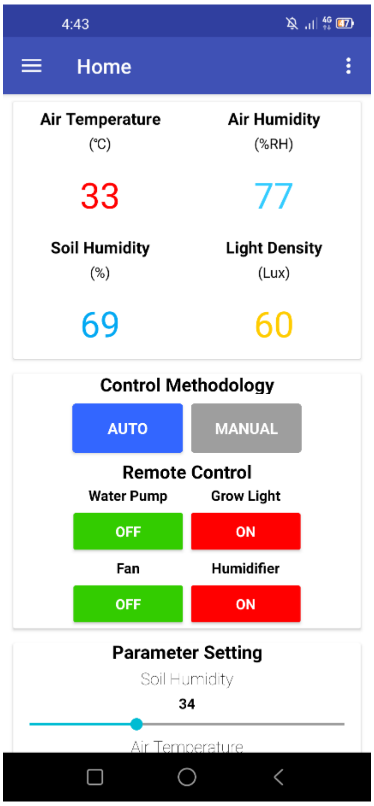


Figure 8: The user interface of mobile application

V. CONCLUSION

A low-cost IoT system for small farm had been developed and implemented successfully in this study. It can be conveniently controlled and monitored various parameters via a mobile application such as temperature, humidity, light intensity and irrigation. The goal of this project is to support the small farm households in monitoring and controlling the environmental parameters that affect directly crop yields. The practical application of this system contributes to the reduction of the production cost by providing just enough irrigation water based on the collected environmental factors. In addition, the environmental information is also stored online that can be used for research, furthermore used as a basis for assessing the quality of agricultural products. In the future, the program optimization for different crops, additional components and functionalities will be carried out.

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VI. REFERENCES

[1] Ricciardi, V., et al., How much of the world's food do smallholders produce? Global food security, 2018. 17: p. 64-72.

[2] Xu, J., B. Gu, and G. Tian, Review of agricultural IoT technology. Artificial Intelligence in Agriculture, 2022. 6: p. 10-22.

[3] Chamara, N., et al., Ag-IoT for crop and environment monitoring: Past, present, and future. Agricultural Systems, 2022. 203: p. 103497.

[4] Ruengittinun, S., S. Phongsamsuan, and P. Sureeratanakorn. Applied internet of thing for smart hydroponic farming ecosystem (HFE). in 2017 10th International Conference on Ubi-media Computing and Workshops (Ubi-Media). 2017. IEEE.

[5] Jaiswal, H., R. Singuluri, and S.A. Sampson. IoT and machine learning based approach for fully automated greenhouse. in 2019 IEEE Bombay Section Signature Conference (IBSSC). 2019. IEEE.

[6] Kim, W.-S., W.-S. Lee, and Y.-J. Kim, A Review of the Applications of the Internet of Things (IoT) for Agricultural Automation. Journal of Biosystems Engineering, 2020. 45(4): p. 385-400.

[7] Mondal, S., S. Ghosal, and R. Barua, Impact of elevated soil and air temperature on plants growth, yield and physiological interaction: a critical review. Scientia Agriculturae, 2016. 14(3): p. 293-305.