RESEARCH ON DEVELOPING A CONTROL AND MONITORING SYSTEM MODEL FOR TEA NURSERY ENVIRONMENT IN THAI NGUYEN

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ABSTRACT

This article focuses on researching the development of a monitoring and control system for various environmental parameters based on the Internet of Things (IoT) to assist farmers in increasing crop yield in tea nurseries in certain areas of Thai Nguyen province. The system utilizes several types of IoT devices such as humidity sensors, temperature sensors, and light sensors to monitor three parameters including humidity, light, and temperature for the plant nursery. Additionally, the study involves building a mobile application that displays information on smartphones to receive data sent from sensors placed in the nursery environment via the Internet. Users can then monitor real-time data and make decisions to control devices such as water pumps for tea irrigation or adjust sensor parameters (increase/decrease, turn on/off light, temperature in the nursery). The testing of the system has shown that it indirectly helps tea growers efficiently manage nurseries, increase labor productivity, and bring about high economic value.

Keywords: IoT control system; IoT monitoring system; smart nursery; Thinkspeak; Internet of Things network.

1. Introduction

The presented research outlines a highly applicable system in the domain of smart agriculture, focusing on the monitoring and control of environmental parameters to optimize plant growth. The system's practical implementation is demonstrated in tea nurseries located in Thai Nguyen province, and its potential extends to broader applications, including weather forecasting in various regions across the country [1-3].

This system is rooted in the principles of the Internet of Things (IoT). The IoT paradigm fundamentally transforms conventional devices into 'smart' entities through the incorporation and synergy of sensors, actuators, and data transmission technologies. Notably, the core functionalities of IoT applications encompass the acquisition of data from devices, the transmission of this data through networks, and the execution of tasks based on the analysis of the collected data [4-6].

As the Internet of Things (IoT) technology proliferates, the deployment of communication-enabled devices has become pervasive across diverse facets of contemporary life. The profound impact of IoT is conspicuous, extending beyond the confines of mere physical connectivity to assert its significant role in various agricultural applications.

Capitalizing on its distinctive advantages, IoT substantially contributes to the enhancement and transformative alteration of multiple dimensions within the agricultural sector. In tandem with the remarkable progress of IoT within agriculture, the authors have undertaken research and formulated a supportive model tailored for several tea nurseries in Thai Nguyen province. This initiative aims to facilitate the production of high-quality tea seedlings on a large scale, addressing an urgent need in the present context with the objective of expanding the cultivation of premium tea trees. It is designed to instill greater impetus for districts in Thai Nguyen province to incorporate smart agricultural practices into their tea production plans.

Hence, the integration of technologies encompassing data collection, analysis, manipulation, automation control, embedded systems, communications, stability, and reliable security has given rise to the Internet of Things (IoT) technology. IoTs are anticipated to yield substantial benefits in supply chain applications, transportation, agriculture, and manufacturing industries, with a particular emphasis on their potential impact in developing countries such as Vietnam [7-10]. Figure 1 illustrates a standard model of a data collection and processing system predicated on IoT communication technology.

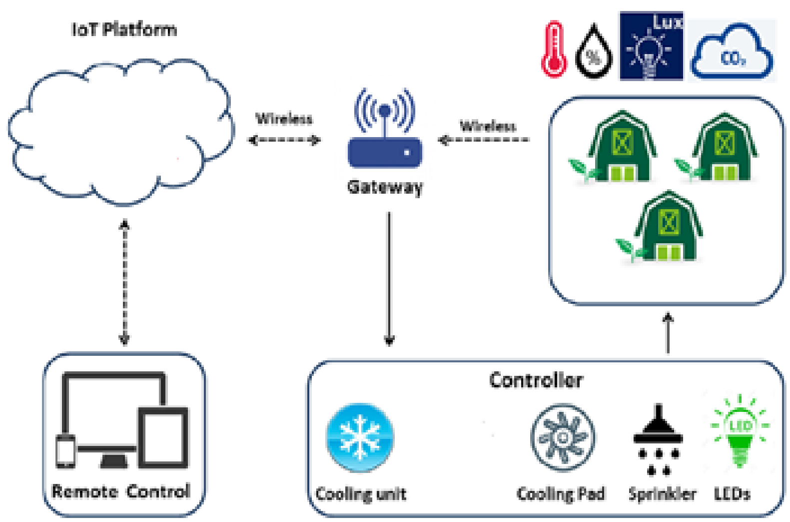

Figure 1: *A standard model of a data collection and processing system predicated on IoT communication technology*

The research system model, illustrated in Figure 1, is designed for the acquisition and processing of data through IoT communication technology. Employed in the context of the tea tree nursery model in Thai Nguyen, the system incorporates three sensor nodes: temperature sensor, humidity sensor, and light sensor employing the HTTP protocol for the collection and processing of data via IoT communication technology. Furthermore, the system features a data server utilizing the IoT platform Thingspeak.com.

2. IoT solutions and HTTP communication protocol

2.1. IoT solutions

The application of IoT solution systems seeks to enhance the efficiency of the current connectivity infrastructure, aiming to generate novel business values and align with an innovative value chain integrated with mobile networks and cloud solutions [1]. IoT extends the functionality of the Internet by facilitating the interconnection of objects. These objects communicate with each other through IP for connectivity [2].

Figure 2: *IoT communication model*

Figure 2 illustrates the operational framework of the IoT communication model, wherein sensors transmit data via wired or wireless communication to the Gateway. The underlying communication processes follow the IoT operating model, utilizing IP for interconnecting objects. The system comprises sensor nodes responsible for gathering data from the external environment, subsequently uploading it to the Cloud or data server through various connections, either directly or through the Gateway. The accumulated data is stored within the system, affording users comprehensive tracking, monitoring, and control capabilities. This data can be accessed and displayed on mobile devices from any location with an active Internet connection [3].

2.2. HTTP protocol

The functioning of the HTTP protocol, as illustrated in Figure 3, constitutes an application-level protocol designed for distributed, collaborative, multimedia information systems. It operates as a stateless protocol situated at the application layer, facilitating communication between distributed systems, and serves as the foundational element of the web [4].

HTTP facilitates communication between various types of servers and clients, primarily utilizing the TCP/IP protocol, although any other reliable protocol can be employed. The interaction between the client and server operates on a request-response pair basis. The client initiates an HTTP request, and subsequently, the server provides an

HTTP response. The HTTP request comprises two critical components: the URL and the verb (method), both transmitted from the client.

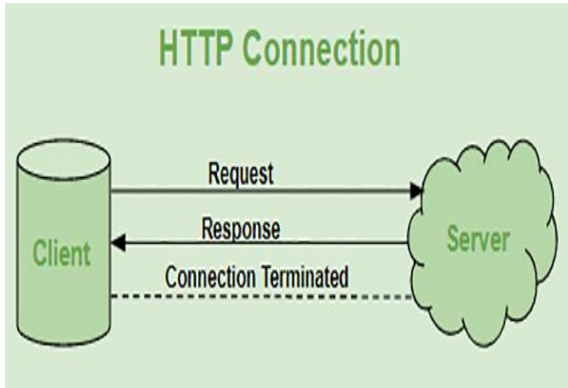

Figure 3: *HTTP protocol operation*

3. System design

Considering the concept of constructing a system in accordance with the aforementioned reference architecture, the system's block diagram is presented in Figure 4, encompassing three primary blocks. Specifically, the central block for data collection consists of sensor nodes, responsible for uploading data to the data server. The server, in turn, incorporates mechanisms for storage and processing.

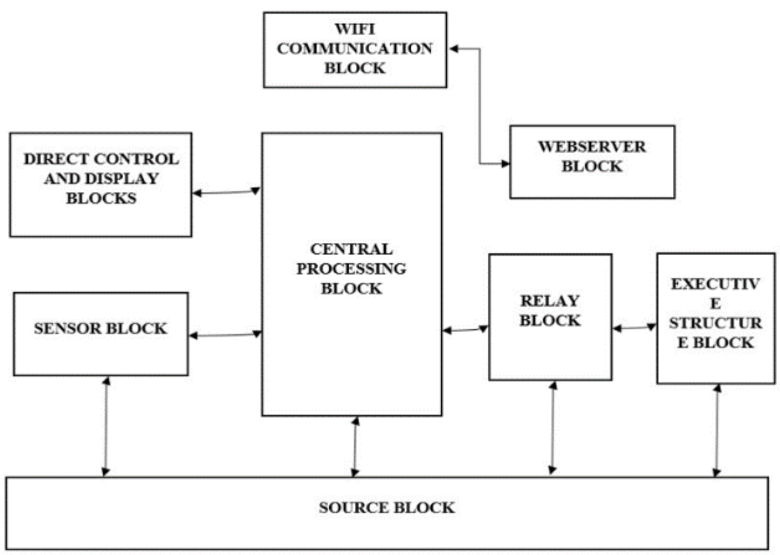

Figure 4: *System design block diagram*

3.1. Data collection and processing block

The Arduino Atmega 2560 microprocessor block depicted in Figure 5 has the function of collecting and processing data from the sensor and posting data to the data server [4].

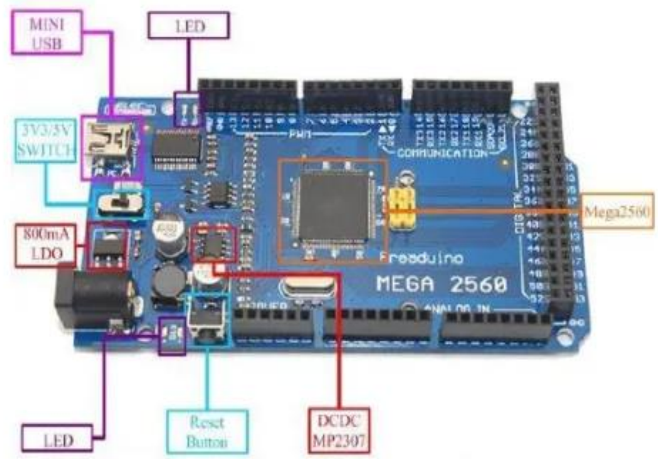

Figure 5: *Arduino Atmega 2560 [11]*

3.2. Temperature sensor block

The principle diagram of the temperature sensor circuit is depicted in Figure 6 with the DHT11 temperature sensor with a measuring range from -55°C to -125°C with error of 0.5°C. DS18B20 is a low power consumption sensor that uses a voltage of 3-5.5V.

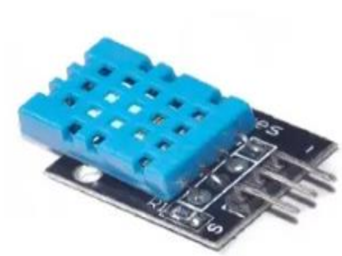

Figure 6: *Actual image of DHT11 sensor [11]*

3.3. Humidity sensor block

Soil moisture sensor circuit diagram is depicted in Figure 7 using LM393 sensor with operating voltage: 3.3 ~ 5V DC, low level output state (0V) if the soil has excess water or soil has moisture high. When the ground lacks water the output will be high (5V). Soil moisture sensors can be used to issue commands to control irrigation equipment in agriculture.

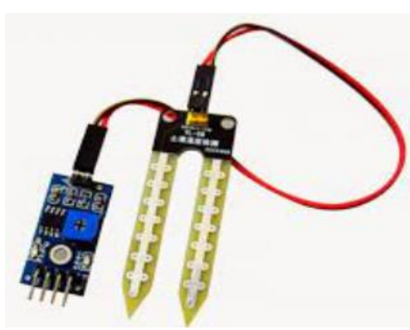

Figure 7: *Actual image Humidity sensor block [11]*

3.4. Light sensor block

The light sensor is depicted in Figure 8 with Photoresistive light sensors most sensitive to ambient light intensity are commonly used to detect ambient brightness and light intensity. When the outside ambient light intensity exceeds a specified threshold, the output of module D0 is a logic low level.

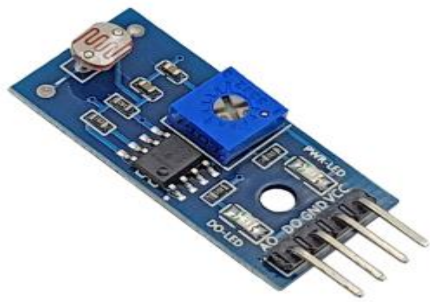

Figure 8: *Actual image light sensor [11]*

3.5. Actual images of the product

Figure 9 depicts an actual image of the product that has been applied to the tea tree nursery model in Thai Nguyen.

Figure 9: *Actual image of the system*

3.6. Internet communication

The process of Internet communication, as delineated in Figure 10, transpires during the data collection phase from Arduino, facilitated through a platform for visualizing and analyzing data within the context of IoT applications. These platforms provide sustained data storage and present visual displays to users. Various free platforms are available for utilization, including but not limited to Xilely, 2lemetry, exosite, carritots, grovestream, thingspeak, and opennenergymonitor. For the present study, the Thingspeak platform is employed.

Figure 10: *Communication to the Internet*

Thingspeak offers a user-friendly registration process and ease of use, making it particularly accessible for beginners through a straightforward API command system. It exhibits efficient long-term data storage capabilities and presents sensor data through intuitive graphical representations. Employing the HTTP protocol, Thingspeak accommodates websites utilizing HTTPS for compatibility with advanced technologies [5].

4. Experimental model using IoT communication

The experimental model is grounded in the foundational framework of IoT communication applied in agriculture, specifically utilizing the LM393 humidity sensor, DS18B20 temperature sensor, and light sensor to monitor three crucial parameters: humidity, light, and temperature for a nursery model. By accessing the values returned by the sensors via the Internet, the monitoring system makes decisions to control devices and modify these parameters [7]. For instance, when monitoring the transmitted parameters from the LM393 sensor, if the humidity falls below the prescribed range (in the case of tea plants, with a recommended humidity range of 60% to 80%), the system triggers commands accordingly. If the reported humidity is below 60%, the system issues a command to activate the water pump for increased soil moisture. Conversely, if the humidity exceeds 80%, the system commands the water pump to be turned off. The channel delay time is set to 3 seconds, ensuring that control commands and data transmission occur within this specified timeframe, which aligns with the system requirements. This approach is deemed acceptable as the system doesn't necessitate stringent real-time constraints. While the system can function entirely autonomously, opting for manual control provides a proactive approach to avoid unnecessary resource consumption. For example, even if the humidity parameter sent from the sensor is below 60%, the system refrains from commanding the water pump if it anticipates rain, demonstrating a more cost-effective strategy.

Similar to humidity control, the tea tree nursery area is equipped with a retractable tarp that can be extended or retracted to modulate light and temperature during sunny days in Thai Nguyen. The tarp is connected to two motors, which, when the temperature sensor detects temperatures exceeding 25°C (optimal for tea plants ranging from 20°C to 25°C), will deploy the canvas to provide shade for the tea nursery. It's essential to note that these initial tests are conducted in a limited area, and the sensors may not be highly accurate. The monitoring and control processes are delineated in Figure 11 below:

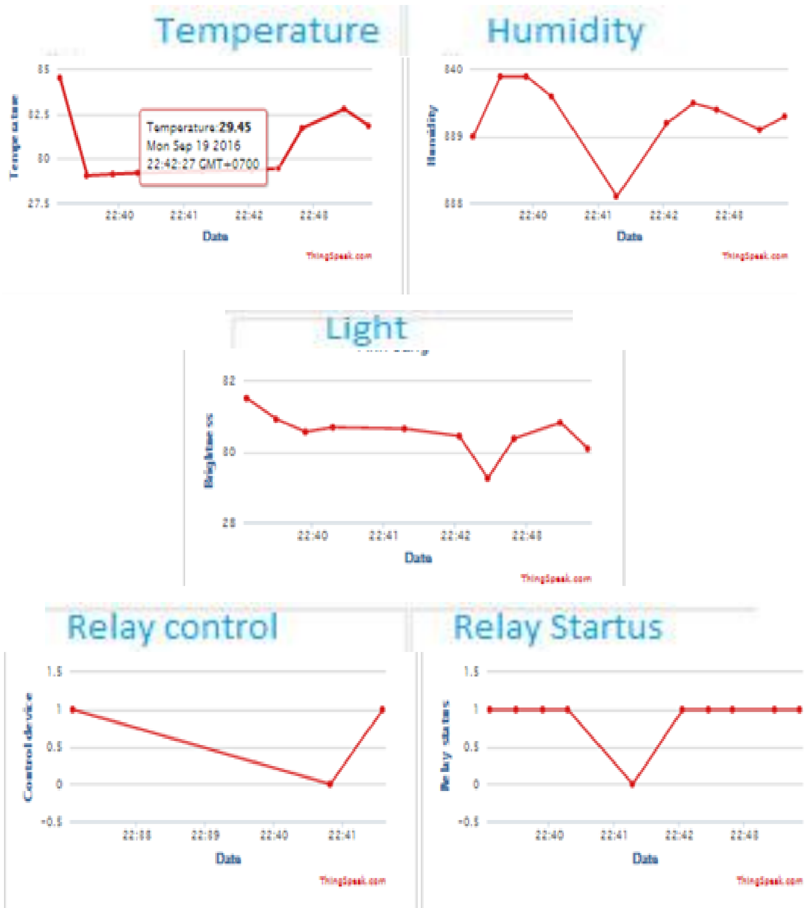

Figure 11: *Results displayed on Thinkspeak.com*

The "on" and "off" buttons in Figure 11 are used to control the device via the Internet and change the parameters of the temperature, humidity, and light sensors. 5 fields of Thingspeak has been used for display, of which 3 fields display sensor parameters and the remaining 2 fields are relay control fields that indicate the control or connection status of the real device.

5. Conclusion

This article delves into the study and construction of an IoT application system model tailored for tea nurseries in Thai Nguyen. Communication techniques have been strategically employed to address several limitations observed in previous system models, encompassing automatic irrigation systems, nursery control systems, and tree planting systems, particularly within the domain of hydroponics for IoT applications. The system outlined in this article is meticulously designed to exhibit high stability, reliable accuracy, an intuitive interface, and easy scalability for customized applications. Furthermore, it has notably overcome key limitations encountered by its predecessors, such as pronounced delays arising from constrained socket processing and protocols, coupled with network latency and delays between measurement sessions, resulting in lags in devices operating in manual mode. In contrast, the system model proposed in this article has undergone thorough experimentation and surveys involving diverse objects, demonstrating relative consistency with simulation results.

This system successfully addresses irrigation and monitoring challenges specific to tea nurseries, leveraging IoT technology to enhance user accessibility. Through the utilization of the Thingspeak platform for IoT applications, the system ensures easy monitoring and interaction with devices closest to individuals. Accessible via common devices such as smartphones or laptops connected to the internet, users can seamlessly utilize all features offered by the model.

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TÓM TẮT

NGHIÊN CỨU XÂY DỰNG MÔ HÌNH HỆ THỐNG ĐIỀU KHIỂN VÀ GIÁM SÁT MÔI TRƯỜNG CHO VƯỜN ƯƠM CÂY CHÈ TẠI THÁI NGUYÊN

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Ngày nhận bài 01/11/2023, ngày nhận đăng 08/01/2024

Bài báo này tập trung nghiên cứu xây dựng một hệ thống giám sát và kiểm soát một số thông số môi trường dựa trên mạng kết nối vạn vật (Internet of Things - IoT) nhằm giúp người nông dân tăng sản lượng cây trồng cho các vườn ươm chè tại một số địa bàn tỉnh Thái Nguyên. Hệ thống sử dụng một số loại thiết bị IoT như: cảm biến độ ẩm, cảm biến nhiệt độ và cảm biến ánh sáng để giám giát ba thông số bao gồm độ ẩm, ánh sáng và nhiệt độ cho vườn ươm cây. Bên cạnh đó, nghiên cứu xây dựng ứng dụng phần mềm hiển thị thông tin trên điện thoại thông minh để nhận các dữ liệu được gửi về từ các thiết bị cảm biến đặt tại vườn ươm qua môi trường Internet. Từ đó người sử dụng có thể theo dõi thời gian thực và đưa ra quyết định điều khiển thiết bị như máy bơm nước để tưới cho cây chè hoặc thay đổi các thông số cảm biến (tăng giảm, tắt/bật ánh sáng, nhiệt độ ươm). Hệ thống thử nghiệm cho thấy đã gián tiếp giúp người trồng chè quản lý vườn ươm một cách hiệu quả nhất, tăng năng xuất lao động và đem lại giá trị kinh tế cao.

Từ khóa: Hệ thống điều khiển IoT; hệ thống giám sát IoT; vườn ươm thông minh; Thinkspeak; mạng kết nối vạn vật.