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Research article

Research on remotely monitoring controller for the drying process of fruit

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ABSTRACT

In the field of agriculture, the conservation of the agricultural products plays a vital role. The challenge in this topic is to manage a large scale of storehouse by manual works. Therefore, an implementation of IoT-based controller for monitoring in preserving fruits such as dragon fruit or jackfruit as a remotely monitored solution. First of all, the analysis of hardware platform and software programming is completed in this work. Several peripheral devices must be deployed in order to send or receive data online. Some sensing boards are also suggested to measure the physical variables such as temperature or humidity. In addition, the overall system is supervised in any time to ensure the whole process. After the procedure of data collection, there is optional filtering method to choose the correct information owing to the large scale of measuring values. Later, a GUI (Graphical User Interface) program is produced to support the system management. Any change in this system would be displayed as soon as possible. This software might be programmed by Visual Studio 2019 using C/C++ language. An operator could open this software in the host computer or mobile device with internet connection. MQTT (Message Queuing Telemetry Transport) protocol is suggested to maintain the data exchange between slaves and host. Thanks to this function, the flow of data could be transmitted fluently and continuously. To verify the effectiveness and feasibility of our approach, several tests are carried out. The system is validated when the environmental conditions are normally obtained. Although there needs several implementations to enhance the system performance, the use of the proposed design in practical system provides the robustness, effectiveness and feasibility for an industrial solution.

Key words: Mechanical design, process control, IoT, user-oriented programming

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INTRODUCTION

Although Vietnamese economy belongs to an agrarian field in the industrial revolution on South East Asia subcontinent, currently with over 80% of inhabitants worked in the domain of agriculture [1–3]. Vietnam is recently one of the greatest fabricator of rice, and one of the most popular exporters in vegetables in the world. Long time ago, majority of these products is damaged or bad quality according to lack of proper drying technology and management of this process. Some reasons which are mainly humid factor and environmental temperature, performs a key component in enhancing the uniform quality in products [4,5]. Henceforth, there is an essential requirement to supervise multi-parameters and remotely monitor system to identify the agricultural quality. In the conventional manner, this job still relies on human practices, such inspecting the thermometer as well as humid measurement manually, supervising it and later indicating the decision for instruction of the system parameters inside the storage [6–8]. Normally, farmers are prone to make mistakes, thus manual control of storage and drying system would upsurge the potential damage to the stored fruit or vegetable. Therefore, an automated drying system is a must that not only could monitor the environmental conditions, but also could synthesize the system data, make decisions and could modify the system parameters owing to the results.

Nevertheless, an intelligent and automated drying system does comprise some troubles and there are several vital specifications which an automated drying machine should have. Firstly, the monitoring functions should be multiple parameters, entirely automated to update, clear, and the data must be visualized to operator in a remotely graphical manner [9–11]. Hence, the collected data should be examined and provided to the system in order to make decision. Consequently, this system could deliver an automated control due to the values of achieved parameters in real time. Some systems [12,13] adds the monitoring features by gathering the data and transmitting them to server. However, it does not analyze the collected parameters. In the other solutions [14,15], the data analysis is additionally included, but then it is too sim-

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ple to carry out any conclusion. Moreover, the synthesis and predictive process on main server ensure the accuracy computation, rapid handling work, and avoid data loss. In the other hand, the system should be completely named as centralized framework. The benefits of centralized system are easily to manage the monitoring and controlling the drying procedure via internet globally [16]. In several cases, the whole management is done in local controller while the server is only updated the system status.

In this investigation, our approach introduces an IoT-based platform for intelligently monitoring and control system in agriculture. The contributions are listed such (1) the proposed framework is entirely centralized network so that users could manage from anywhere around the globe, (2) the powerful ability in synthesis, analysis and making decision is featured in this system and (3) the controllability of drying process is enhanced since many environmental parameters, i.e. pressure, temperature or humidity, are continuously managed. The content of this paper is organized as follow.

METHOD OF RESEARCH

The overall system could be divided into two parts: physical system and cyber system as Figure 1. In the first part, it senses the information and gathers the input data in a specific format. It might include several measuring sensors, slave controller, power source and so on. Sensing devices are utilized to estimate the physical values in environmental conditions such pressure, temperature or humidity. Slave controller collects particular data from various sensors, then transmits it to cloud.

In the second part, this system obtains the information that consist of the identification of optimum constraints for storage, identification of any fault, promising the storage for optimum duration and managing the procedure of the drying process. It could produce a command which is forwarded to the local station. Moreover, the server system could store data and also produce analytical charts that would be appeared on the website or the mobile program for better effects of data. The micro-processor normalizes the system constraints governing unit in respect to the feedback from server. These data frames comprises the variation of parameters demanded by users.

To support further development, users could integrate the more advanced sensors, additional devices or mechanical actuators in order to extend the flexible application for the industry. Furthermore, the implementation of software in cyber system allows multi-connections from different users. Otherwise, the intelligent algorithms, for instance artificial intelligence, machine learning or adaptive control, could cover wide range of applications.

HARDWARE DESIGN AND SPECIFICATIONS

Centralized controller

The design of V2403 Series as Figure 2 is based on the industrial standard, compact size, easy to obtain many signals to programmable logic controller, desktop, micro-processor or embedded computer. This controller is typically utilized for several solutions in M2M, IoT, smart transportation and so on.

Figure 2: Embedded computer V2403

Slave controller

Raspberry Pi as Figure 3 is an embedded computer which includes a 1.8 GHz dual-core micro-processor that operates up to 30 I/Os. It also has small battery and some ports which could be linked to different kinds of both sensing devices and actuators in order to measure the changes of environment, and also execute powerful computations on the logged data if necessary. Commonly, some lite operating systems such Linux or Raspbian, are installed in which its embedded to assemble the collected data and process it as per condition. To support graphical user interface, this board has one Ethernet port, Wi-Fi communication and HDMI connection to link it to a host PC. Generally, it is a robust, inexpensive and mini-size computer that has suitable processing capabilities and needs for the establishment of each node.

Temperature and humidity sensor

The proper module of measuring multi-function DHT11 as shown in Figure 4, was introduced. With the highly sampling frequency up to 1 Hz, it would assist the monitoring system to collect the required data, while this sensor does not cost much due to its hardware. The reasonable precision of temperature and humidity measurements is a wonderful tool for operators to integrate in their IoT-based project. In some advanced applications, the vertical motion of system

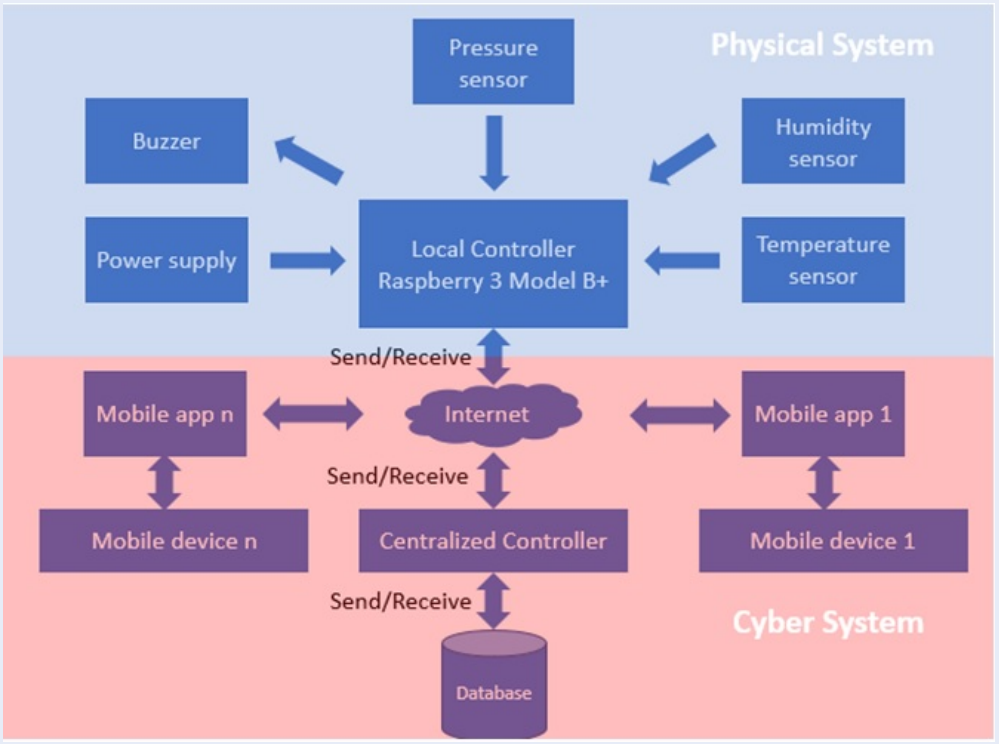

Figure 1: Proposed framework for IoT-based system

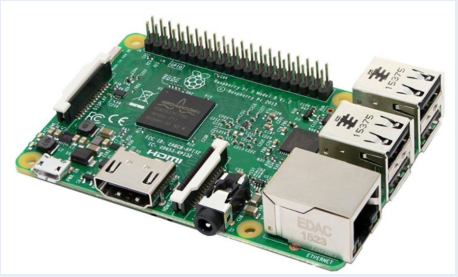

Figure 3: Raspberry Pi 3

Figure 4: DHT11 sensor

is logged according to the inertial sensor MPU-6050 which has capability to estimate the movements in 3D space and to receive analog data back to the main CPU. Though it is extremely sensitive, some improper evaluations of the vibrating angle are inevitable. As a result, this board inclines to oscillate when external factors such driving torque or moment occur. Hence, filtering solutions—for instance, a Kalman filter or a complementary filter—should be implanted to avoid drifting.

Pressure sensor

In Figure 5, air and liquid pressure sensor MPS20N0040D-S 0~40KPa pressure sensor is used as an electronic manometer to measure the pressure of air, liquids (usually water, other substances please see the datasheet of the sensor.) helps to realize a multitude of different applications: liquid

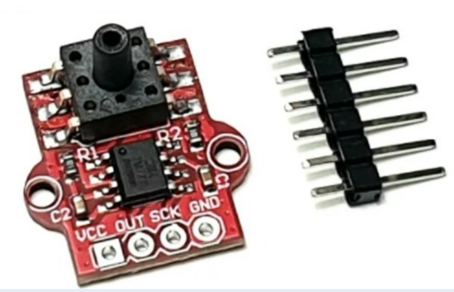

Figure 5: MPS20N0040D-S sensor

level sensing, air pressure in sealed vessels„ sensors using 2-Wire interface are easy to use and connect with sample code that can available on any platform of micro-processor.

Power source

In the IoT-based developments, engineers are presently able to discover more efficient method for power management in their designs. For a wide range of applications such automotive, electronics consumer and industrial fields, these developments would support to execute at lower voltages. It often grants the larger opportunity for more reliable solutions to the harvesting energy topics, that are quickly popular as a requirement of renewable energy resources.

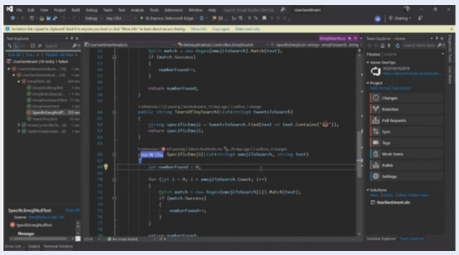

Figure 6: Programming environment of VS2019

SOFTWARE DESIGN AND COMMUNICATION

Software design

To implement the IoT-based features into practical platform, it is required to deploy the advanced programming languages such C/C++, Java or PHP. There is a trend for many developers to embed the visual program into web-based application by Visual C++. Henceforward, in our approach, the package of Visual Studio 2019 as Figure 6 that includes many libraries for communication protocol, framework of .net extension, is considered as the primary programming software.

Web application

For the communication between slave and server, client would demand for a website to host if the cyber address is correct. The proposed system contains many sensing nodes which consist of the functional blocks discussed above, transmits the logged information to a local controller from where it is made, analyzed into a web page as Figure 7. And then it is conducted to the client side as a HTML-based file that is extracted into a website in the browser of client. In our case, Django which is the Python-based framework of the free and open-source website, becomes an excellent choice for proposed system. It is launched according to the model-view-template architectural pattern.

Android application

It is recognized regularly that android operating system is one of the most famous one in mobile devices. The android application is a software-based tool which meant to operate on the mobile device installing the android operating system. Therefore, the proposed system delivers an android application as Figure 8 which could be easily created by Android Studio. This software development kit is an integrated programmed environment in the commercial market. This application fundamentally introduces all the technical specifications of a web-based solution in mobile phones.

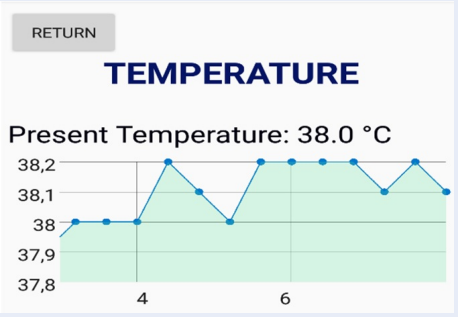

Figure 8: Android-based app of proposed system

Communication protocol

Message Queuing Telemetry Transport-MQTT is the network protocol to publish or subscribe in IoT-based

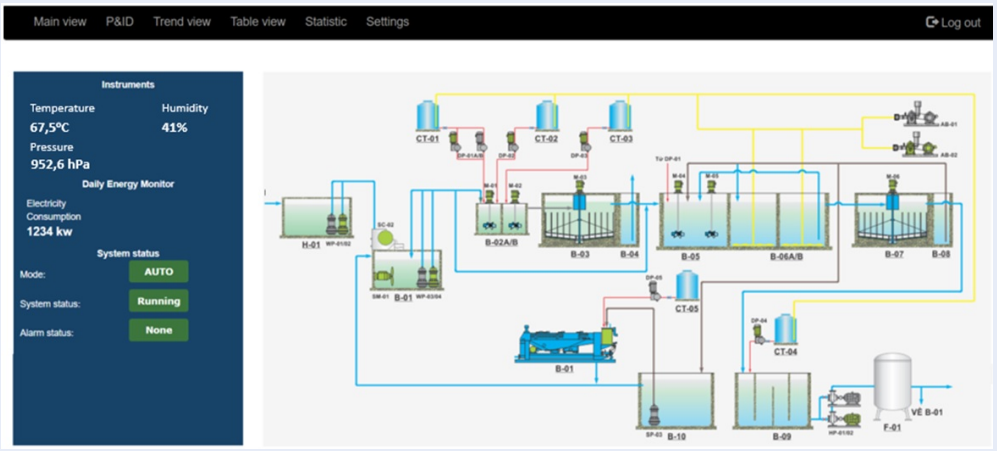

Figure 7: Web-based interface of proposed system

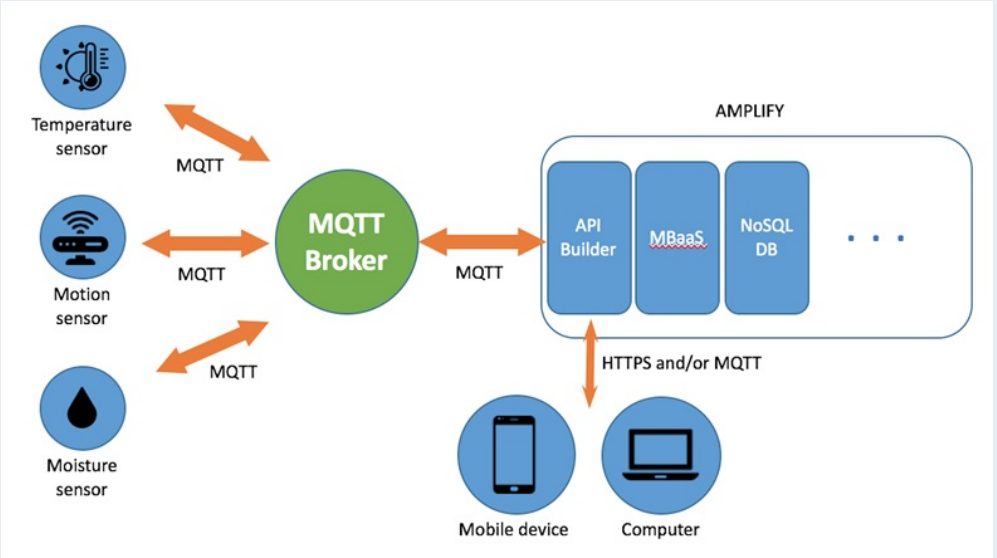

Figure 9: Flowchart of MQTT communication

devices. It has low bandwidth, highly reliable, duplex communication, and is well-matched with most of the operating systems. The network framework for communication was illustrated as Figure 9, in which various clients could be linked to the server—so-called as MQTT broker. Each client records the specific channel and publishes the corresponding information; subscribed their activities which is measured as registration. Owing to the kinds of messages, the database is characterized as control and feedback. The host pushes the control command and receives from external modules to the slaves. The feedback message, consisting of the status of node as well as the acknowledge signal, is transferred back to server from many slaves. By deploying this network protocol, this system could avert data loss in the process of message transmission.

RESULTS AND DISCUSSIONS

To validate the working procedure of our system, the overall hardware is experimented in practical scenario. The system is connected with several kinds of sensing devices via SPI communication which needs three pins (Rx, Tx and clock) to handle. Data is received frequently, however, it is only stored in local controller depending on sampling period. The wireless protocol is the bridge interface between centralized controller and local controller. Then, data is

Table 1: Parameters of system simulation

Item		Temperature	Humidity	Pressure
Current		17,4^{o}C	81,0%	959 hPa
7 days	min	10,2^{o}C	13%	951,4 hPa
	max	38,9^{o}C	81,8%	960,7 hPa
60 days	min	10,2^{o}C	13%	951,4 hPa
	max	43,5^{o}C	81,8%	960,7 hPa
Total	min	10,2^{o}C	13%	951,4 hPa
	max	43,5^{o}C	81,8%	960,9 hPa

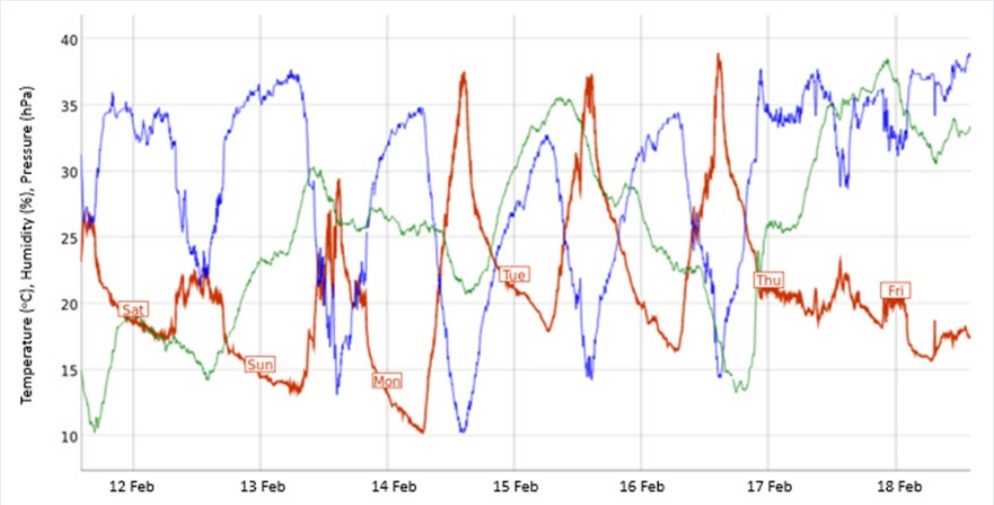

Figure 10: Experimental result of monitoring data

saved in cloud for easily accessing if required.

The statistical information could be achieved as Table 1 for each period: 7 days, 60 days and average. The current values are only available at one time while the others are meaningful in tracking progress and monitoring. The overall process is visibly illustrated as Figure 10. It could be seen clearly that the drying system is manipulated and supervised on-the-fly.

CONCLUSION

In this paper, an intelligent IoT-based system in agriculture is presented. The cyber-physical structure of this system is demonstrated in detail with peripheral components. The development of both software and hardware is completely mentioned so that the entire platform is the systematic approach. Since some laboratory tests are carried out in real-world application, it is verified that the feasibility, effectiveness and robust monitoring function are approved.

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CONFLICT OF INTEREST

All authors declared that there is no conflict of interest in this study.

AUTHOR CONTRIBUTIONS

Conceptualization, T.H. Nguyen; Methodology, T.N. Nguyen; Software, H.Q.T. Ngo; Validation, A.H. Vo; Formal analysis, A.H. Vo; Investigation, M.T. Nguyen; Writing—original draft preparation, M.T. Nguyen; Writing—review and editing, H.Q.T. Ngo.

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Research article

Nghiên cứu về bộ điều khiển giám sát từ xa dành cho quá trình sấy trái cây

Nguyễn Tuấn Hoà, Nguyễn Thanh Nhân, Võ Anh Huy, Nguyễn Minh Tuấn, Ngô Hà Quang Thịnh*

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TÓM TẮT

Trong lĩnh vực nông nghiệp, việc bảo tồn các sản phẩm nông nghiệp đóng một vai trò quan trọng. Thách thức trong chủ đề này là quản lý quy mô lớn kho bằng các công việc thủ công. Do đó, việc triển khai bộ điều khiển dựa trên IoT để giám sát trong bảo quản trái cây như thanh long hoặc mít như một giải pháp giám sát từ xa. Trước hết, phân tích nền tảng phần cứng và lập trình phần mềm được hoàn thành trong công việc này. Một số thiết bị ngoại vi phải được triển khai để gửi hoặc nhận dữ liệu trực tuyến. Một số bảng cảm biến cũng được đề xuất để đo các biến vật lý như nhiệt độ hoặc độ ẩm. Ngoài ra, hệ thống tổng thể được giám sát trong bất kỳ thời gian nào để đảm bảo toàn bộ quá trình. Sau quy trình thu thập dữ liệu, có phương pháp lọc tùy chọn để chọn thông tin chính xác do quy mô lớn của các giá trị đo lường. Sau đó, một chương trình GUI (Giao diện người dùng đồ họa) được tạo ra để hỗ trợ việc quản lý hệ thống. Bất kỳ thay đổi nào trong hệ thống này sẽ được hiển thị càng sớm càng tốt. Phần mềm này có thể được Visual Studio 2019 lập trình bằng ngôn ngữ C / C ++. Người điều hành có thể mở phần mềm này trên máy tính chủ hoặc thiết bị di động có kết nối internet. Giao thức MQTT (Message Queuing Telemetry Transport) được đề xuất để duy trì trao đổi dữ liệu giữa nô lệ và máy chủ. Nhờ chức năng này, luồng dữ liệu có thể được truyền một cách trôi chảy và liên tục. Để xác minh tính hiệu quả và tính khả thi của phương pháp tiếp cận của chúng tôi, một số thử nghiệm được thực hiện. Hệ thống được xác nhận khi đạt được các điều kiện môi trường bình thường. Mặc dù cần có một số triển khai để nâng cao hiệu suất của hệ thống, việc sử dụng thiết kế được đề xuất trong hệ thống thực tế mang lại tính mạnh mẽ, hiệu quả và tính khả thi cho một giải pháp công nghiệp.

Từ khoá: Thiết kế cơ khí, điều khiển quá trình, IoT, lập trình hướng đối tượng

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