REMOTE AGRICULTURE AND AUTOMATION CONTROL USING INTERNET OF THING (IoT) DESIGN AND IMPLEMENTATION

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ABSTRACT

The shortage of labor in agriculture is increasing day by day. The solution in this regard is the replacement of human labor with automation and remote control. Cloud computing and IOT technology is an important part to drive and raise the agricultural productivity and quality control like industrial output. This article presents the structure of remote control and automation farming systems. It is divided into two parts. First an automated system that receive information from various types of Sensors and Actuators. Then send the data to the cloud system, with the back-end to process and analyze data to send commands to control the equipment in the farm. Another part get information from the cloud to the decision-makers to control the environment in agricultural areas beyond the capabilities of automation. The process of both will complement each other for the ultimate in modern farming.

KEYWORDS: Cloud Computing, Internet of Things (IoT), Smart farm, Remote Agriculture, Network, Sensing, Internet

1. Introduction

Today's farming is changing according to the development of urban society. Farmer career is a career that can be done alongside other occupations. The model is a holiday agricultural switch to work in normal working days. There are limits to traveling to remote areas of the city. Making agriculture work is just a hobby that can not be expected. Even the hiring of workers to work instead of high costs may not be worth the investment, capital, labor and time to solve the problem is bringing technology to help solve the problem.

Automated farm systems are the basic technology used in agriculture to reduce human labor. Including the timer function like watering and fertilizing plants. Ventilation from the nursery house to reduce the temperature. The timing is based on the data that needs to be manipulated, how long and how many variables will be appropriate. And when you set up your device and want to change it, you need to set up a new system. The settings must be adjusted until the system is stable. At this point, the development of an automated control system has led to the inspection and input of the processing equipment to control plant management and the environment. Sensors are responsible for monitoring the environment and transmitting information such as temperature and humidity to the processor and controlling the various factors in agriculture. The work will vary according to the monitoring system, so that the agricultural inputs are more appropriate. Reduce errors from unexpected effects. However, there are many factors involved in agriculture. Automated farm systems that can even control agricultural inputs, but have limitations. Applicable only to some types of agriculture. And there must be control over other environments besides control.

IoT technology (internet of Thing) is an automatic development to the next level by connecting the data from the farm equipment to the Internet. Reduce distances limitations in agricultural management and diversify farming concept to a wide range. [1]. Antonis Tzounis presents the theme and challenges for the development of IoT applications in agriculture. Comprehensive design, structure and technology with the type of agriculture. The model of Implemented System is designed at the workshop, Lingzhi Mushroom Farm in Thailand [2], which controls humidity, temperature and data transmission to farmers with IoT Technology. [3-5] Design and implementation IoT system with Smart Farm and Cloud Computing. [6-7]. Management of information obtained from various parts of the Smart Farm system, which requires a lot of data and requires real-time recording. [8-10] Introducing the IoT Framework and IoT Platform for Agriculture and the protocol interfaces for the IoT application to the urban agriculture. Urbun farming is offered in the form of vertical farming. [11] It takes up less space farming and uses technology to manage. A variety of Smart Farm applications are included in the Modeling the Smart Farm [12], which can be used to design Smart Farm systems.

In this paper aims to present the management of agriculture with IoT. Remote Agriculture is a remote farming system where farmers can manage their production, monitoring, and remedial resources for agricultural land from any location. Connect via the Internet. It is a system that works with automation systems that farmers are familiar with using smart farm models and integrates with Iot technology. Precision farming is based on the ability and experience of farmers to tackle the problem and conditions issue. The automation system does not work to the extent that it can substitute for human judgment and experience. So in early IoT technology should have a system that enables both part of the automated system and human-controlled systems work together.

2. Conceptual Design

Management of agricultural areas with technology is to reduce labor force as much as possible. The management system consists of 1. The substitution of the routine basic functions of the agricultural system with automation. 2. Use self-decisioning data input from the sensor device. 3. The work order system provides the equipment to handle the farmland according to the requirements set. 4. The system connected to the Internet to send data to the cloud database. 5. The display uses the data retrieval from the cloud to display the data of agricultural plots to farmers. 6. Farmers analyze data and consider refining the automation settings or control the equipment in the farm to solve the problem.

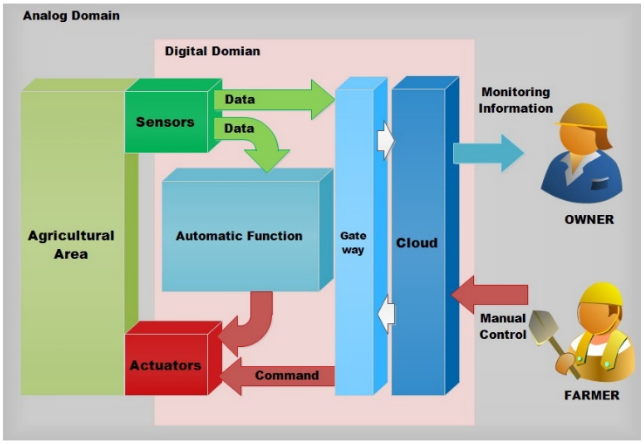

Figure 1 Logical conceptual of Remote Agriculture and Automation control system

Figure 1 shows the structure of the connection from the farmland to the sensors and actuators for automatic data transmission and the manual control by the farmers, through the connection of the Internet with the cloud system is the point of gathering information from the agricultural area. And is shown through the interface in many ways. Farmers are provided with information to make decisions in handling unexpected events. And beyond control with automation. Additional management to reduce system vulnerabilities.

3. Remote and automation Layers Model

The structure of the remote and automation system is illustrated in Figure 2. It consists of several layers separating the functions of each part. The hardware from the layer below is responsible for the various commands of agricultural work, controlled by the next layer, which is responsible for the task. The control later transmission data from the first layer, there are connections between the various parts of the network from small and private networks to public Internet networks. Networking is an important part of extending our management system to have no boundaries. Farmers can manage the farmland from anywhere. The most important part of the system is the cloud database.

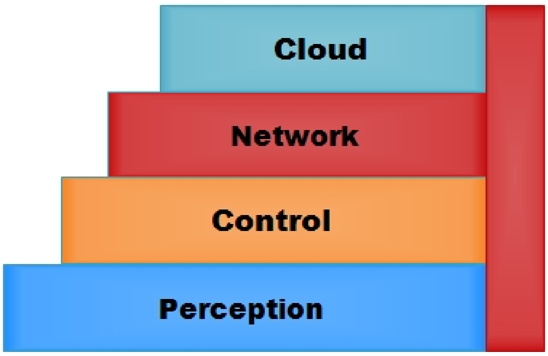

Figure 2 Remote and Automation Agriculture layers Structure

The concept of using IoT technology is a part of connecting existing automation systems to the Internet. This connection property can also be used to manage data that is included with the database on the cloud. Data is sent and stored in Time series on the database. And it can be used as needed to display information to farmers. Network connections can also send commands to control IoT devices. This is a two-way communication for the purpose of presenting this paper.

3.1 Perception Layer

There are two types of devices in this layer: Sensors and Actuators. It is the source and destination device of the whole process.

1. Sensors generate information from the environment monitoring by the type of sensors. The number and type of sensors are appropriate for the type of agricultural work. And according to the resolution of the system used.

2. Actuators are devices that are ordered to control the system from the control unit by automatic or direct work from the farmer. Key devices include power on / off switch, motor and position control device.

3.2 Control Layer

Microprocessor is the primary device used to collect data from sensors and execute actuators via the microprocessor platform interface. Microprocessor Selection that design of Ports require to Connect to Sensors and Actuators and the ability to convert data in the form of Analog to Digital (ADC) and Digital to Analog (DAC) like a gateway of Analog and Digital Information. If the system is large, the control layer will be distributed into a sub node. Each Node connects the sensors or actuators according to the number of ports.

3.3 Network Layer

Network is a LAN (Local Area Network) and Wide Area Network (WAN) according to the characteristics of the agricultural area and limitations of owner care. including the cost of connecting to the Internet. The development of a convenient system should be developed to connect with the standards of widely used wireless networks. Because there are many support devices and there are easy connections.

1. Local Area Network (LAN) is the network where the owner manages all the connections. The signal in the network as internal data transmission. Suggested formats include, Low-power wireless connection. The internal device connects to a network like WSN. The control layer is then transferred to the Internet via WAN Connection.

2. Wide Area Network (WAN) is a connection to the Internet. It may be a direct connection from node sensors or a connection from a LAN. The technology connected to the WAN depends on the convenience of the ISP (Internet Service Provider) in that area. If

it is a direct connection from Sensors or Node to the Internet, Wireless WAN service such as 4G [10]. is the suggestion choice.

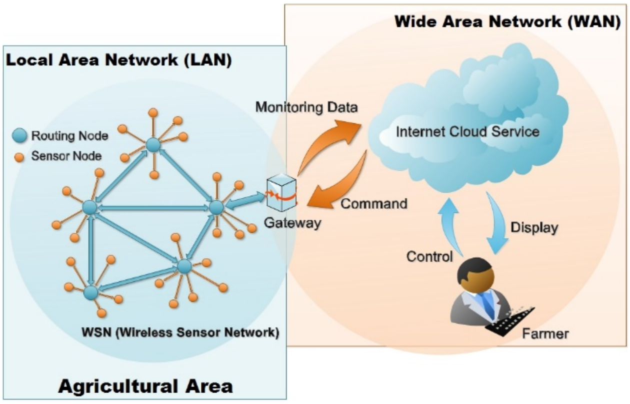

Figure 3 Network connection with Remote and Automation Agriculture

3.4 Cloud Layer

Cloud is a service from the Internet as well as everyday utilities like electricity, water. The concept of cloud is to pay for internet services. It does not have to be own Infrastructure. IoT-based agriculture is connected to the cloud service to store data on the cloud and use data through connection by Web service or other method. Include the Web or Application Interface to control access to the control layer over the Internet. It is part of the Cloud deployment as well.

JavaScript Object Notation (JSON) is a standard text-based format for representing structured data based on javaScript object syntax. It is commonly used for transmitting data in web applications [13-14]. JSON is the recommended format for sending data between IoT devices and cloud services. With simple layout, low power consumption, can be used to process data in various types. Microprocessor is easy to create JSON format and send it to the JSON cloud database as well. Then, using the Web service, can use JSON directly. It is suitable for use with Agri-IoT [8].

```
<script>
var myObj, myJSON, text, obj;

//Storing data:
myObj = { "name":"John", "age":31, "city":"New York" };
myJSON = JSON.stringify(myObj);
localStorage.setItem("testJSON", myJSON);

//Retrieving data:
text = localStorage.getItem("testJSON");
obj = JSON.parse(text);
document.getElementById("demo").innerHTML = obj.name;
</script>

</body>
</html>
```

Figure 4 JSON Data Format Example

4. Implementation

In this section we introduce our method of agriculture task for solving problems caused by environmental changes or resource management to agricultural plots, both automatic and manual control. Also introduces the device used to implement the mechanism for each type of factor.

4.1 Irrigation and Fertilization

Sensors: Soil Moisture Sensor [15] and Humidity Sensor are installed in the soil to measure the moisture content in the soil. EC (pH) Sensors [16] and NPK Sensors are used to measure the composition of the fertilizer to the correct ratio, in systems with fertilizers to the water system.

Actuators: Solenoid water valves [17] and pumps are ordered when the system decides which areas require water and fertilizer. The system may be timed or monitored by sensors and can be ordered directly from the farmer through the system's application.

Figure 5 Soil Moisture Sensor, EC (pH) Sensor and Solenoid water valve installation

4.2 Humidity

Sensors: Humidity Sensor installed to measure air humidity. Use multiple measurement methods and average moisture content of agricultural areas.

Actuators: Fog Pump Control Switch works with spray nozzles [18]. To spray mist, water, and air humidity for nursery house requiring moisture, such as Mushrooms House.

4.3 Temperature

Sensors: Thermometer for temperature measurement in agricultural areas.

Actuators: Ventilators vent hot air out of the nursery house. Or use air conditioning to reduce the temperature.

4.4 Light

Sensors: Light (LDR) Sensor measurement of intensity and the change of light.

Actuators: Light Control Switch [19] controls on / off light Bulb to compensate for light on the day have many cloud, or for plants that need long lasting light during the day. Including the opening of the lamp to heat the dehumidifier and increase the temperature inside the nursery house.

Figure 6 Fog spray nozzles and light Bulb for plant

4.5 Diseases and Pests control

Factors that are used to prevent, rather than correct are building nursery houses. Defining area of disease free and quarantine. This paper proposed monitoring and detection of plant diseases and pests trap for relieve the damage.

Sensors: Camera with image processing this section also requires further research into the use of agricultural. Figure 7 show the Plant Diseases on NDVI Image for analyze.

Actuators: Light Trap to lure insects out of farmland to reduce it. Heater to prevent diseases from moisture, such as fungus, also uses other actuators to reduce the risky factors and insect damage.

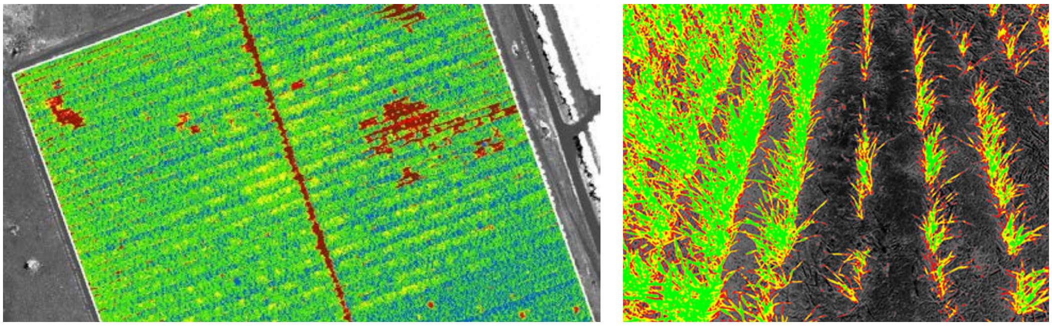

Figure 7 Plant Diseases on NDVI Image [20-21].

5. Discussion

In comparison, human labor and automation system, there are comparative examples in reference research Consideration is divided into two parts. One is the replaced wage with automate system. Another one is all the system development costs. The labor cost, in Thailand, was 300 baht per 8 hour working day. It would cost 9,000 baths per month. The cost of small IOT development system is around 3000 baht, including Microprocessor board Sensor and Output module (excluding motor output) ,plus the electricity bill is about 400 baht per month.

It would be cheaper if compare automate system and manpower in the same job and same period. More ever IoT system was long life of use approximately 3 to 5 years. It depends on the electronics device used, and the new technology replacing our system.

Table 1 The comparison the cost between IoT system and human to small farming management in a month

Labor cost	Bath	System cost	Bath
1 month		System Device	3,000
		Electricity cost	400
	9,000		3,400

6. Conclusion

This paper, we have presented a conceptual design and implementation of remote and Automation agriculture using IoT Technology. It is the management of farmland that reduces the number of laborers are replaced with technology. But because of the complexity of agriculture, there are some factors that also depend on human experience and decisions. The system has both automatic and manual parts. Enhanced by the Internet through reduced distance. System development is at the heart of the performance of sensors and Node Microprocessor to be more capable. It can control more and more factors. There may be no human involvement in the system at all.

References

[1] Antonis Tzounis, Nikolaos Katsoulas, Thomas Bartzanas, Constantinos Kittas. Internet of things in agriculture, recent advances and future challenges. Biosyst Eng 2018;164:31-48.

[2] Ekkarat Boonchieng, Oran Chieochan, and Anukit Saokaew. Smart farm: applying the use of NodeMCU, IOT, NETPIE and LINE API for a Lingzhi mushroom farm in Thailand. IEICE Trans Inf Syst 2017;E101–B.(NO.1):16-23.

[3] Ahmed Khattab, Ahmed Abdelgawad and Kumar Yelmarthi. Design and implementation of a cloud-based IoT scheme for precision agriculture. 28th International Conference Microelectronics (ICM); 2016 Dec 17-20; Cairo, Egypt; 2016. p. 201-204.

[4] Minwoo Ryu, Jaeseok Yun, Ting Miao, Il-Yeup Ahn, Sung-Chan Choi and Jaeho Kim. Design and implementation of a connected farm for smart farming system. IEEE SENSORS 2015; 2015 Nov 4-1.Busan, South Korea; 2015. p. 1-4.

[5] Fan TongKe. Smart agriculture based on cloud computing and IOT. Int J Adv Comput Technol 2013;8:2.26.

[6] H.Bach and W.Mauser. Sustainable agriculture and smart farming. ISSI Scientific Report Series. 2018;15:261-69.

[7] Prem Prakash Jayaraman, Ali Yavari, Dimitrios Georgakopoulos, Ahsan Morshed, Arkady Zaslavsky. Internet of things platform for smartfarming: experiences and lessons learnt. IEEE Sensor 2016; 2016 Oct 30–Nov2. Orlando,FL,USA; 2016.16:11.

[8] Andreas Kamilaris, Feng Gaoy, Francesc X. Prenafeta-Bold´u, Muhammad Intizar Ali. Agri-IoT: a semantic framework for Internet of Things-enabled smart farming applications. 2016 IEEE 3rd World Forum on Internet of Things (WF-IoT). 2016 Dec 12-14. Reston, VA, USA; 2015.p.442-447.

[9] Vinod Sukhadeve, Sahadev Roy. Advance agro farm design with smart farming, irrigation and rain water harvesting using Internet of Things. International Journal of Advanced Engineering and Management. 2016;1.1:33-45.

[10] Asad Abbas, Muhammad Taha Jilani, Muhammad Khalid Khan. Comparative analysis of wireless technologies for Internet-of-Things based smart farm. Sci Int (Lahore) 2017;29(2):373-8.

[11] Yap Shien Chin, Lukman Audah. Vertical farming monitoring system using the Internet of Things (IoT). AIP Conference Proceedings 2017;1883:020021.

[12] Michael J. O'Grady, Gregory M. P. O'Hare. Modelling the smart farm. Information Processing in Agriculture 2017;4:179-87.

[13] JSON [Internet]. JSON (JavaScript Object Notation) [updated 2018 March 10; cited 2018 Mar 14]. Available from: http://www.json.org/

[14] Working with JSON [Internet]. [updated 2018 March 14; cited 2018 Mar 14]. Available from: https://developer.mozilla.org/en-US/docs/Learn/JavaScript/Objects/JSON

[15] Soil moisture [Internet]. [cited 2018 Mar 14]. Available from: http://sgvmwd.org/CONSERVATION/Rebates/Soil-Moisture-Sensor.

[16] EC sensor install [Internet]. [cited 2018 Mar 14]. Available from: http://www.allinstrumentation.com/measurements/analyzers/potentiometric-ph-measurement-working-principle/.

[17] Solenoid valve [Internet]. [updated 2018 Feb 20; cited 2018 Mar 14]. Available from: http://www.koianswers.com/discussion/2102/my-way-of-automating-aeration-of-koi-pond-in-case-of-power-failure-using-a-solenoid-valve-/p1.

[18] Fog nozzle [Internet]. [Updated 2018 Jan 18; cited 2018 Mar 14]. Available from: http://www.techmark-inc.com/akimist.html.

[19] Light bulb control [Internet]. [cited 2018 Mar 14]. Available from: http://www.rambo.tw/product-detail.php?product=69.

[20] NDVI [Internet] [cited 2018 Mar 14]. Available from: https://garudauav.com/drone-survey-india-agriculture/.

[21] NDVI [Internet] [cited 2018 Mar 14]. Available from: https://agribotix.com/blog/2014/06/10/misconceptions-about-uav-collected-ndvi-imagery-and-the-agribotix-experience-in-ground-truthing-these-images-for-agriculture/.

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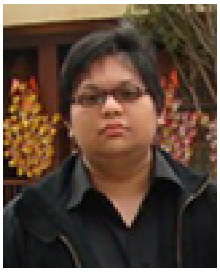

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