Applying Image Processing and Edge Computing for Plant Growth Monitoring in Smart Farm

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Abstract.

In the history of development economics, smart farming has been thought of as a key factor in agriculture more efficiently. It is necessary to integrate various technologies to deploy in the process of production and cultivation. The aim of this study was to apply and evaluate information technology technique with agricultural engineering in order to reduce the monitoring process for farmers. This research was applying Image Processing techniques to assist in cultivation by measuring plant growth and plant health through webcam. The image of plant will calculate on Edge Computing in Raspberry Pie 3. The results will be displayed as a percentage of plant growth. In addition, this process can be performed the Smart Farming through the Internet of Things (IoT) technology and Edge Computing. The system will control the environment such as temperature, humidity, light, heat, pH in the greenhouse is appropriate for the growth of plant automatically. The results of this study indicate that plants growing faster is to increase productivity and reduce workload for farmers. The current findings add substantially to our understanding of techniques for processing plant growth from low resolution images in order to be suitable for real farmers' use. The results from the research are satisfactory. The evidence from this study indicates that 80.95% accurate for low resolution images.

Keywords. -

1. INTRODUCTION

Agriculture in many countries around the world are still agriculture based on human labor. It is also a dependency on the environment, climate factors, mainly external factors which will affect the product received. Many counties want to change from traditional agriculture today to modern agriculture that focuses on management and technology become Smart Farming. In order to develop farmers to be able to do agriculture more efficiently, have more labor-saving devices, reduce work procedures for farmers and increase productivity.

It is necessary to bring various technologies to modify in the process of production and cultivation. This research is applying information and communication technology including the knowledge of agricultural technology to developagriculture as much as possible. In order to reduce the processes in working for farmers. This research applied the Image Processing techniques to monitor with cultivation by measuring plant growth and plant health through Webcam. It will show the results as a percentage of growth. This result can be connected to the Smart Farm through the Internet of Things (IoT) to help control the environment in greenhouse. For example, controlling the temperature, humidity, light, heat, pH in the greenhouse is suitable for the growth of that plant automatically. Resulting in plants growing faster, this increase productivity and reduce workload for farmers to become Smart Farmer. The knowledge gained from this research will be process the growth of plants from low resolution images. The rest of this paper is organized as follows. Section 2 provides a brief overview of some theory and related works which had to be implemented within this research. Then, in Section 3, the system designs of hardware and software components are presented in detail. The experimental deployment is presented in Section 4 to demonstrate the design. Including the measurement results and performance are presented. Finally, conclusions are drawn in Section 5 and following with acknowledgement section.

2. RELATED WORKS

Research that has been processed to increase agricultural productivity is divided into 4 main areas as follows.

1. Checking for the Plant Growth
2. Checking for the Plant Health.
3. Plant Disease Detection
4. Pest Detection and Identification

The image analysis and processing system has a high potential for evaluating plant growth and health with high accuracy. Automatic image analysis system is flexible to use. In the development of automated inspection tools for plant growth and health assessments. The image analysis is often included in mechanical equipment to replace manual assessments by humans [1]. Also, to control the operation of the machine. There are 5 main steps in image analysis: image recording, preanalysis, segmentation, detection and classify [1] Image processing can reduce the total data of the image to a manageable level. By adding edges and making geometric corrections before analysis, measurement, and specifying some specific details such as size, area, and shape [6]. The most important benefit of image analysis is able to see specific areas and contrasting colors. This helps with visual explanation and interactive analysis by computer. The images that are analyzed can also be stored in a large memory. When computers are connected to the internet, it becomes very easy to transfer data between scientists from cities or countries [6].

Leister [2] was using digital video and visual analysis that shows to determine the size of plants without destroying by measuring the leaf area. The system provides non-destructive methods for evaluating plant growth and growth rates by examining and quantifying plant parameter parameters. Other studies, such as plant growth and health in a controlled environment, are continuously monitored by Kacira and Ling, [5] were using visual inspection methods. The back area is also an important variable related to plant growth. In addition, the growth of plants is clearly associated with dry weight. Measuring the area of the bushes of plants or in other respects covered by image processing methods can provide valuable information for monitoring plant growth [3].

Trimi Neha Tete and Sushma Kamlu [10] have used image processing techniques for the detection and classification of different leaf diseases that exist. This system helps to detect and analyze plant diseases automatically. By using images to inspect organisms such as fungi, bacteria, viruses, etc. In order to help farmers, reduce costs in the analysis of diseases and causes of that plant disease.

2.1. Image Processing

Image Processing is the image to be processed or calculated using a computer to get the information we need both in terms of quality and quantity. There is an important step that are to make the image sharper, eliminating noise from images. The segmentation of the object that interests us from the image. In order to take the picture of the object to analyze for quantitative data such as the size, shape and the direction of movement of the object in the picture. Then we can analyze these quantitative data and create a systematic to use in various fields such as grading or quality grading systems for agricultural crops. It can be seen that these systems require a lot of image processing and is a process that must be repeated in the most original form which works in these ways if human beings analyze themselves often requires a lot of time and labor. Also, if it is necessary to analyze a large number of images. The image analyzer may be tired. It can result in errors. Therefore, computers play an important role in performing these functions on behalf of humans. It is also known that the computer has the ability to calculate and process huge amounts of data in a short time [4]. Therefore, it is very useful in increasing the efficiency of image processing and analyzing the data obtained from the images in various systems mentioned above.

2.2. Edge Computing

Edge Computing is data processing that is as close as possible to data sources. In the form of data analysis statistical data processing which instead of taking a large amount of data to process on the Cloud, it takes that data to process at the source closest to the data source or edge itself. The main reason why the processing needs to be at the edge is latency. Edge Computing has the advantage of speed in data transfer, bandwidth and privacy & security. [9]. To monitor and control the Smart Farm, we work as Edge Computing technique for processing on Raspberry Pi3.

2.3. Internet of Things (IoT*)*

IoT means many "things" connected to the internet so they can share information with other things - IoT applications, connecting devices, industrial machines, and more. Built-in sensors to collect information and in some cases do so devices and machines that connect IoT can improve the way people work and live [7]. For example, the Internet of Things in the real-world ranges from smart homes that automatically adjust heat and light to intelligent factories that monitor industrial machinery for finding the problem, then adjust automatically to avoid failure [8]. Many sensors had been added in this research.

3. SYSTEM DESIGN AND ARCHITECTURE

3.1. System Architecture

Detailed information about the microcontroller board, its features, and the capabilities of each model. In this research has 3 microcontroller boards consist of Arduino UNO R3, Node MCU ESP8266 and Raspberry Pi 3 which are designed to be suit for each function.

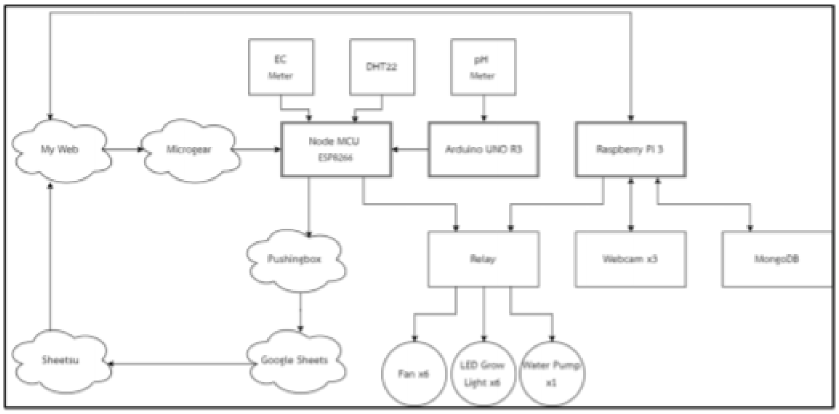

Figure 1 System Architecture

3.2. System Design

These three boards have different capabilities, such as the Node MCU ESP8266 has the ability to connect to Wi-Fi, but the problem is that there is only one analog channel. Arduino UNO R3 boards are required to receive the analog value and then sent to the Node MCU ESP8266 board for storage at the Google Sheets, but the two boards mentioned above. There is also a downside: there is no USB port for this, which requires a USB port for taking pictures of plants in a greenhouse using a webcam.

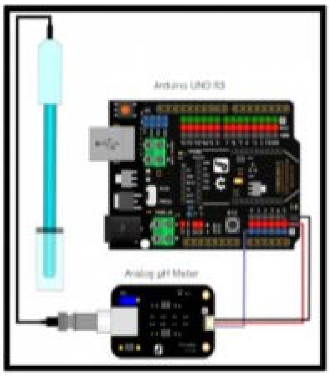

Figure 2 Analog pH Meter Connection

Analog pH meter is a pH sensor that measures the pH of a solution in the range 0-14. The output is analog (0 - 1023) 5v. Analog EC Meter is a sensor for measuring the electrical conductivity of soil nutrients for soil tillers. The web page can also display the values stored on Google Sheets. It can also instruct the Node MCU ESP8266 board to send the value received from the sensor to Google Sheets by pressing the button from the page. The webpage will send a working order to the Microgear. The Microgear will then send the order to the Node MCU ESP8266 board. For detecting plant growth, the system will be taking a photo on a web page. The webpage will send a photo order to the Raspberry Pi 3 board. The Raspberry Pi 3 board will then take a picture using the three webcams connected. Then take the image to be stored on the memory card of the Raspberry Pi 3 board itself, which web pages will be called photos stored on the Raspberry Pi 3 board to display on another page. This is a process of Edge computing.

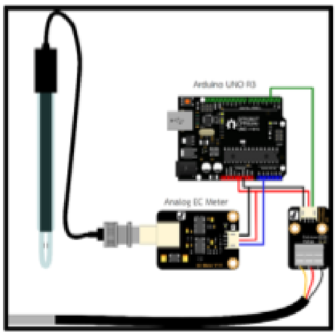

Figure 3 Analog EC Meter connection

3.3. Image Processing Methodology

Detailed information about the microcontroller board, its features, and the capabilities of each model. In this research has 3 microcontroller boards consist of Arduino UNO

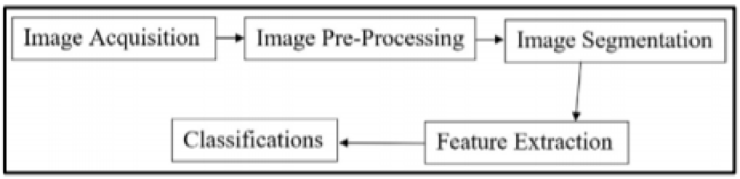

Figure 4 Image Processing Methodology

First, the images of plants are acquired using a WebCam. Then image processing techniques are applied to the acquired images to extract useful features that are necessary for further analysis. These images are in the form of RGB (Red, Green, and Blue). Second, pre-processing is a progress of the image data that enhances some image feature necessary for the next processing. In this process, image enrichment is done for increasing the contrast of the image. Colour conversion of RGB to Gray image is done using following equation:

$$f(x) = r * 0.2989 + g * 0.5870 + b * 0.114 \quad (1)$$

For image segmentation can be done using Thresholding, K-mean cluster, converting RGB to HIS (hue, saturation, intensity) colour model. Image thresholding is an effortless and efficient way of distribute an image into a foreground and background. Then, masking the green pixels, the green coloured pixels mostly represent the healthy and growth area of the plant. The next step is counting the green pixels and calculate the growth percentage.

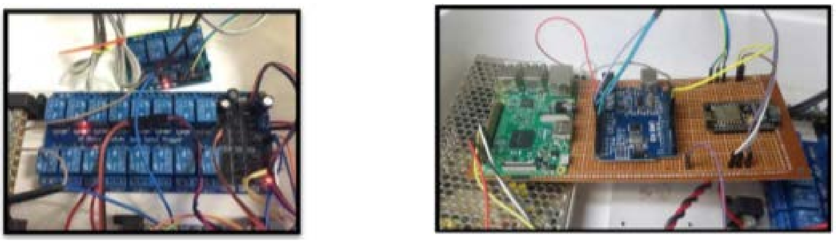

Figure 5 The sensor circuit and IoT controlling

4. RESULTS

The results of the sensor circuit and IoT controlling part are shown in the Fig 5. The circuit connected to the pH sensor and the sensor circuit used for conductivity measurement (EC) and the relay connection to control the operation of various electrical equipment. Once it has started, the microcontroller will execute commands on the various devices and sensors used. The system can be monitored by observing the operation of the LED grow light or other electrical equipment of the system, with the timing of the device through the relay. Relay is in the control of the microcontroller.

The image from the webcam will be processed at Raspberry Pie 3. The image processing procedure is described in Section 3.3. The result of the processing will be as shown in Fig. 6. The image on the left was an RGB image obtained from the camera. The image on the right is the image after processing.

Figure 6 Output of image processing method

Due to this research aims to use image processing to analyse the percentage of plant growth, therefore, in Fig.7 it shows the results when the plant grows which the processing steps will remain the same.

Figure 7 Output result of image processing method

In this experiment, the webcam is set to automatically take a picture to be processed once a day at 1 pm every day and then calculate the percentage of growth. The information obtained will be displayed on the website as shown in Fig 8.

For supporting smart farming, the operation of the equipment will be automated such as the operation of LED Grow Light, which will be scheduled to work. Also, it stops working like the ventilator, and the water pump will work according to the conditions set. Sensor values will be measured and send the data up to Google Sheets. Fig 9 and 10 show the result from Google Sheets.

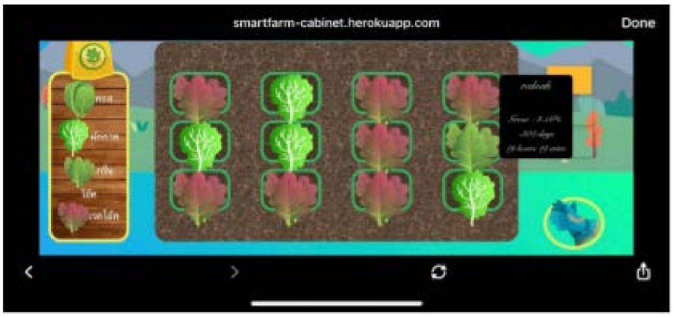

Figure 8 The percentage of growth display on the website

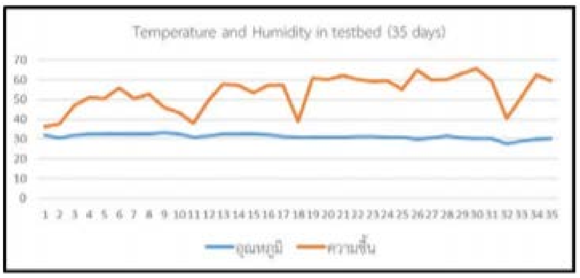

Figure 9 Show the result of Temperature and Humidity

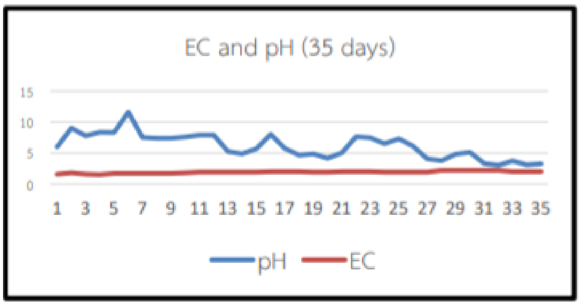

Figure 10 Show the result of pH and EC

5. CONCLUSION

This research was applying Image Processing techniques to assist in cultivation by measuring plant growth and plant health through webcam. The image of plant will calculate on Edge Computing in Raspberry Pie 3. The results will be displayed as a percentage of plant growth. The system will control the environment via IoT such as temperature, humidity, light, heat, pH in the greenhouse is appropriate for the growth of plant automatically. The current findings add substantially to our understanding of techniques for processing plant growth from low resolution images in order to be suitable for real farmers' use. The results from the research are satisfactory. The output results, there were 240 errors from a total of 1260 times. The evidence from this study indicates that 80.95% accurate for low resolution images.

6. ACKNOWLEDGMENTS

This research was funded by King Mongkut’s University of Technology North Bangkok. Contract no KMUTNB-63-DRIVE-17. We would like to deliver our greatest appreciation for their support.

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