MONITORING AND LEARNING OF PLANT GROWTH AND HEALTH FOR EFFECTIVE SUPPLY OF WATER, NUTRIENTS AND PESTICIDES IN LARGE SCALE PLANTATIONS

Dinithi Prabodhani Jayasuriya
Department of Electrical and Electronic Engineering,
Faculty of Engineering,
University of Sri Jayewardenepura,
Sri Lanka.
dinithijaya@gmail.com

Dinithi Prabodhani Jayasuriya
Department of Electrical and Electronic Engineering,
Faculty of Engineering,
University of Sri Jayewardenepura,
Sri Lanka.
dinithijaya@gmail.com

Shanilka Udari Illankoon
Department of Electrical and Electronic Engineering,
Faculty of Engineering,
University of Sri Jayewardenepura,
Sri Lanka.
shanilkaudari@gmail.com

Dr. Chamitha De Alwis
Senior Lecturer,
Department of Electrical and Electronic Engineering,
Faculty of Engineering,
University of Sri Jayewardenepura,
Sri Lanka.
chamitha@sjp.ac.l

***Abstract*—Agriculture sector is a major economic force in Sri Lanka, making a significant contribution to the national economy. However, it is observed that land and human resources available in Sri Lanka for agriculture becomes scarce. On the other hand, the demand for high quality agricultural products is on the rise. Therefore, we need to embrace cost efficient and effective technologies that would facilitate the automation of large scale plantations to obtain an increased yield per given area. Providing water, nutrients, pesticides and other supplies is one of the most resource consuming tasks in a large scale plantation. Existing solutions to achieve this objective are only capable of providing supplies from time-to-time without knowing the exact requirement of the plant. This may result in a shortage or excess amount of supplies that will adversely affect the health of plants. In response, the proposed method is capable of identifying the exact status and health of plants to customize the supplies accordingly and ensure the healthy growth of plants. When it comes to this project, almost the total management of the plant is done by the system from the beginning to end. Initially the system decides the age of the plant and learn about the required conditions. An array of sensors and cameras connected through Narrowband Internet of Things (NB-IoT) will collect data that will be processed using machine learning techniques. Initially image processing is supposed to do the object detection and to perform the leaf counting task it is intended to consider the capability of deep convolution neural network. Automatic detection of these type of issues in plants is supposed to achieve by a software solution for automatic detection and classification of plant leaf diseases. This would facilitate the understanding of plant growth and any development of pests or weeds. Water, nutrients and pesticide will be supplied according to the exact requirement of plants. In addition, the proposed system will alert if immediate attention is required in case of an emergency and also report on the growth of plants and usage of each type of supplies to facilitate a thorough insight of the plantation. Because, when it comes to a traditional farm, farmers have to pay their attention to each and every plant separately to identify factors like diseases, insect attacks or any other infections. Therefore, farmer's special attention have to be taken in such kind of situations. It is envisaged that the proposed system will play a pivotal role is automating large scale plantations that would in return benefit the agriculture sector In Sri Lanka**.

Keywords: Soil moisture sensor, Water level sensor, Humidity sensor, Temperature sensor, Raspberry-pi

I. INTRODUCTION

Agriculture is more trending in modern world because quality and organic foods are the main concerns over anything. Still traditional strategies are more popular in the agriculture industry and hence there's no any significant improvement so far. Proposed project is mainly for the individuals who have the craving but have limitations with allocating time. This paper depicts a technology to control and monitor the plant growth with extremely low human intervention while learning and processing its changing conditions. After all this system make the client aware about the critical circumstances of plants like insect attacks, diseases or any other sudden occurrences.

When we dive into the design a micro controller is used to solve plants thrive by tracking the environmental conditions and monitoring them. Then the system itself compares the existing conditions with the pre entered data and decides the suitable supplies and other facts. The application gives a timely alert to the user's Android phone by gathering and analyzing the data collected from the sensors.

At the initial stage we hope to design the system for a particular set of the relevant plant. Suppling water, nutrients and pesticide according to the stage of the plant was the one of major role to be achieved through this project. By the researches, it was finalized to use Tomato for testing of the project because it has several clear stages in its life span. In this case we design the system to decide the age of the plant at the beginning of the process. Therefore, it's better to choose a plant species which is having several stages in its life span. Applying this concept for the plants which don't clearly show stages of the life span is a future implementation of this project.

II. LITERATURE REVIEW

A similar research works have been carried out this area all over the world. One has done in a tomato greenhouse on the south of Italy by Mancuso et all. The air temperature, relative humidity and soil temperature are measured using Sensicast devise with wireless sensor network. Web-based plant monitoring application has also been developed. The Greenhouse user can read the measurements over the Internet.

If some measurable variable changes rapidly, then an alarm will be sent to the owner‘s mobile phone by SMS or GPRS. In one minute interval the bridge node gathers data from other sensor nodes and transmit the measurements of temperature and relative humidity Smart plant monitoring, research was done by Teemu Ahonen et al. He did the research in the Martens Greenhouse Research center in Narpio town in Western Finland. Likewise many more similar research works have been implemented in several places .Some are based on Bluetooth and some are based on Wi-Fi technology as well.

Smash and atal have proposed an approach to direct water in rural fields [1]. Zhou Zhongwei and at al have proposed a technique to picture and follow rural items in inventory network [2]. M.K. Gayathri and at al advance the quick improvement of agrarian modernization and help to acknowledge brilliant answer for horticulture and productively explain the issues identified with ranchers [3]. Bo Yifan and atal have concentrated on the investigation on the use of distributed computing and the web of things in horticulture and ranger service [4].

Ayush Kumar and at al utilized IoT and picture handling to locate the supplement and mineral insufficiencies that influence the yield development [5]. Li Sanbo and at al centre around the equipment engineering, arrange design and programming process control of the exactness water system framework [6].

In this proposed project, though the initial stages are looks like similar with those researches we hope to compare the current status of the plant with the threshold values. Then the system itself decides the amounts of supplies which should be released to each plant and alerts will be sent to the farmer in emergency situations.

III. METHODS AND MATERIALS

A. Working Principle

In spite of the fact that there are numerous systems existing to automate the watering and fertilizing process, this system mainly focuses on optimizing the supplies and monitoring the state of the plant throughout its life span. Initially the life span of the plant is divided into four phases. Those are Young seeding/Early growth, vegetative growth, flowering and fruiting. These stages rely upon the plant and for the initial execution we chose Tomato. As shown in Fig.1, there can be seen main four stages in tomato. It was selected for the research level processes as Tomato is very appropriate with the project requirements. Fruit information and mature fruiting are two intermediate stages in Fruiting stage. The number of leaves is the parameter that is going to be used in order to decide the stage of the plant. Real time images are taken using a camera and deep convolutional neural networks are used to perform this task. The next important function is to decide the condition. This is accomplished by detecting the color and shape of the leaves using image processing techniques. Here we have given a set of images of leaves. Based on these two results the system moves to the next process which is providing the supplies and alerts. If the plant is not healthy an alert is transmitted to the farmer’s mobile phone and if it is healthy the watering and fertilizing is done based on the age automatically. Water, nutrients and pesticide will be supplied according to the exact requirement of plants and those amount are deciding according to the sensor outputs. Threshold values are defined for each conditions of the plant. An algorithm developed with threshold values of temperature and soil moisture is programmed into a microcontroller-based gateway to control water and fertilizer quantity.

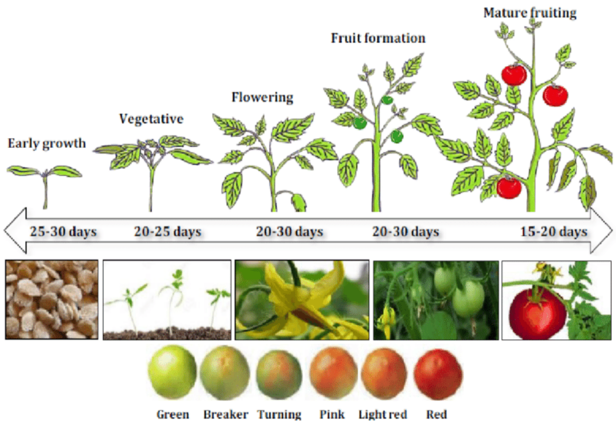

Fig 3: Stages of a Tomato plant

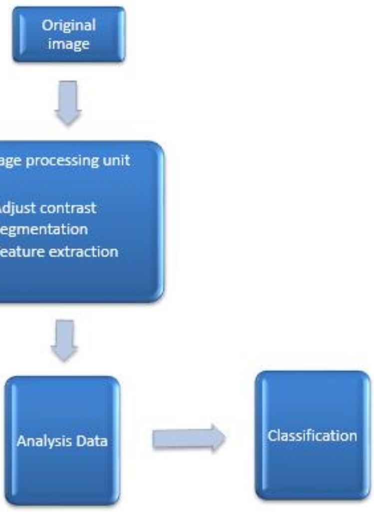

Fig 4: Steps of Image Classification

B. Methododology of detecting the condition

This chapter describes the technology and the process that we decided to follow when deciding the plant’s healthiness. It is done by leaf classification. First process is getting the image acquisition by using the camera unit. Fifty sample healthy leaf images and fifty sample unhealthy leaf images are taken and then image processing method is used to extract the features. Lastly, the collected data will be classified into healthy or unhealthy by using ANN techniques.

Fig. 2 shows the steps of image classification of leaves. Processing is done in three ways before the analyzing stage.

C. Materials

Soil moisture sensor is used to detect the moisture level and it is connected to the microcontroller by using an amplifier. Based on the inputs originating from the sensor units and from the age detection unit, the system decide the amount and the fertilizer type. Then using a relay it controls the valves of the containers (water and fertilizers) and furthermore the main control unit itself generates the alert messages whenever required.

Raspberry pi is used for the data processing part. Status of the plant is monitored all the time and if there's a plant which needs special attention, it will be sent the alert signal to farmers via Raspberry pi and thus providing emergency situation detection. All sensors are successfully interfaced with microcontroller and the microcontroller is interfaced with the raspberry pi. GPS and camera are also connected to raspberry pi. The sensors give input to the controller and according to that microcontroller controls the devices in auto mode and also sends the value of sensors to raspberry-pi and raspberry-pi forwards it to the user's smart device using the internet.

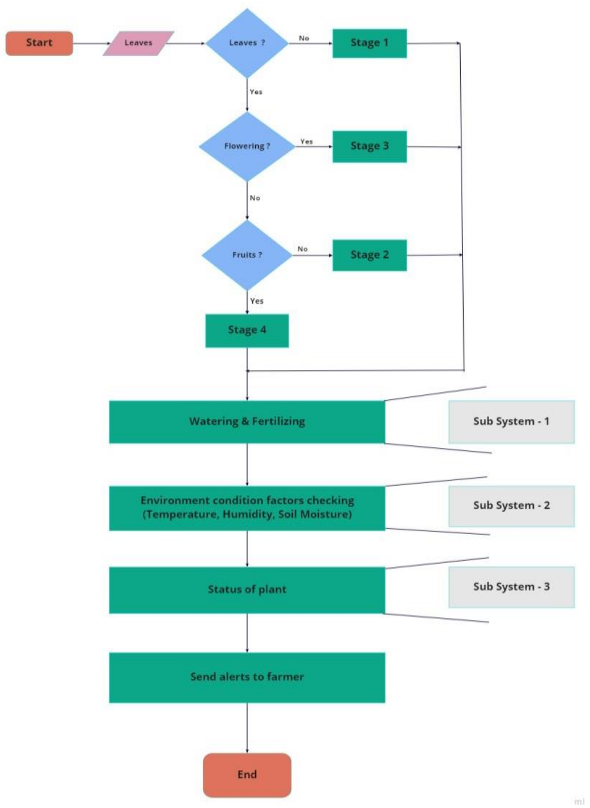

Fig 3: Method Overview

Age detection unit: As mentioned in the diagram below, the camera unit is fixed to monitor the plant continuously. Then those real time images are compared with the given samples and decide the actual stage. Here the whole deciding process is done by raspberry-pi. Then a signal which contains the decision is passed to the main control unit.

IV. SYSTEM OVERVIEW

Hardware:

A. AVR Microcontroller Atmega 16/32:

The microcontroller going to use is, Low-power AVR 8-bit Microcontroller, having 8K Bytes of In-System Self-programmable Flash program memory, Programmable Serial USART, 8-channel, 10-bit ADC, 23 Programmable I/O Lines.

B. Temperature Sensor LM35:

The LM35 is a precision IC temperature sensor. Output voltage of LM35 is directly proportional to the Centigrade/Celsius of temperature. This LM35 does not require any external calibration or trimming to provide accurate temperature range and it's a very low cost sensor. It has low output impedance and linear output. The operating temperature range for LM35 is -55° to $+150^{\circ}$C. With rise in temperature, the output voltage of the sensor increases linearly and the value of voltage is given to the microcontroller which is multiplied by the conversion factor in order to give the value of actual temperature.

C. Moisture sensor:

Soil moisture sensor is used here to measure the water content in soil. It uses the property of the electrical resistance of the soil. The relationship among the measured property and soil moisture is calibrated and it may vary depending on environmental factors such as temperature, soil type, or electric conductivity. Here, it is used to sense the moisture in the field and transfer it to the microcontroller in order to take the controlling action of switching the water pump ON/OFF.

D. Humidity sensor:

The DHT11 is the sensor which is going to be used as it's a basic, low-cost digital temperature and humidity sensor. It gives out digital value and hence there is no need to use a conversion algorithm at ADC of the microcontroller and hence we can give its output directly to data pins instead of ADC. It has a capacitive sensor for measuring humidity. The only real shortcoming of this sensor is that one can only get new data from it only after every 2 seconds.

E. Water level sensor:

Water level buoys sensor, otherwise called drift balls, are round, tube shaped, have a place or correspondingly melded items, produced using either unbending or adaptable material, that are light in water and different fluids. These are non-electrical equipment every now and again utilized as visual sight-markers for surface outline and level. They may likewise be joined into switch instruments or translucent liquid tubes as a segment in checking or controlling fluid level.

F. Raspberry Pi:

The Raspberry Pi is a small pocket size computer used to do small computing and networking operations. It is the main element in the field of internet of things. It provides access to the internet and hence the connection of automation systems with remote location controlling devices becomes possible. Raspberry Pi is available in various versions. Here, model Pi

2 model B is used and it has quad-core ARM Cortex-A53 CPU of 900 MHz, and RAM of 1GB. it also has: 40 GPIO pins, Full HDMI port, 4 USB ports, Ethernet port, 3.5mm audio jack, video Camera interface (CSI), the Display interface (DSI), and Micro SD card slot.

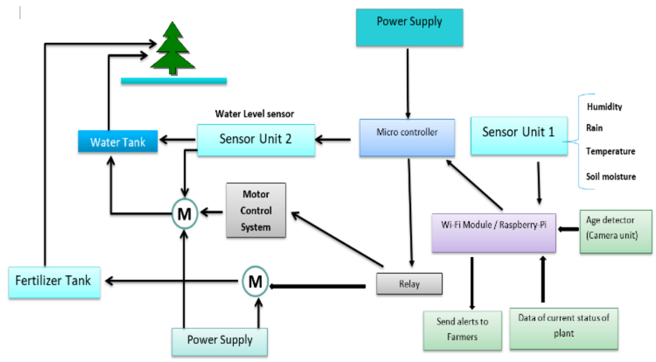

Fig 4: System Overview

Software Packages:

A. Raspbian Operating System:

Raspbian operating system is the free and open source operating system which is Debian based and optimized for Raspberry Pi. The basic set of programs are provided by this and operating Raspberry Pi is done. It comes with around 35,000 packages which are pre-compiled software that are bundled in a nice format for hustle free installation on Raspberry Pi. It has a good community of developers which runs the discussion forms and provides solutions to many relevant problems. However, Raspbian OS is still under consistent development with a main focus on improving the performance and the stability of as many Debian packages as possible.

B. SinaProg:

SinaProg is a Hex downloader application with AVR Dude and Fuse Bit Calculator. This is used to download code/program and to set fuse bits of all AVR based microcontrollers.

C. Dip Trace:

Dip race is EDA/CAD software for creating schematic diagrams and printed circuit boards. The developers provide multi-lingual interface and tutorials (currently available in English and 21 other languages). Schematic Capture Editor, PCB Layout Editor with built-in shape-based auto router and 3D Preview & Export, Component Editor, and Pattern Editor are the four modules that the Dip Trace has.

D. Proteus 8 Simulator:

Proteus 8 is one of the best simulation software for various circuit designs of microcontrollers. It has almost all microcontrollers and electronic components readily available in it and hence it is a widely used simulator.

E. AVR Studio Version 4:

It is used to write, build, compile and debug the embedded c program codes which are needed to be burned in the microcontroller in order to perform desired operations. This software directly provides a .hex file which can be easily burned into the microcontroller.

V. DISCUSSION

A. Collection of Samples

Fig 5: Few Samples of Healthy leaves

Fig 6: Few Samples of Unhealthy leaves

Fig. 5 is an example for the sample of healthy leaves we gathered. Likewise, 50 sample images are stored in the system. Pixel for green area should be obtained for detecting the healthiness of the respective leave. When taking the samples, we highly concerned to include as much as different types of healthy leaves as it may lead to a higher accuracy of the project. Therefore, 50 samples were our target.

In the same way, samples for unhealthy leaves were also collected as In Fig. 6. These samples play a major role in the project as all the decisions are going to base on the classification of input image.

B. Image processing and Analysis

The analyzing based on two main catagories. Results are based on color pixels and area pixels. When cosidering about the color of the leaf, the number of green color pixels are higher in healthy leaves and based on that the classification can be done. (Healthy leaves its around 15k pixels while unhealthy leaves it is around 100pixels) The process for deciding the total area is in several steps like getting the input image, resizing the image, turning it into grayscale, segmenting the image and then taking the number of pixels. When considering about the classification based on area pixels it’s higher in healthy leaves than unhealthy leaves. Lastly the 50 samples of healthy leaf and 50 samples of unhealthy leaf analyzed and calculated using the smple ratio based on area and color pixel.

$$Ratio\ based\ on\ color = \frac{Green\ Pixel}{Area} \quad (1)$$

$$Ratio\ based\ on\ Area = \frac{Area\ Unhealthy}{Area} \quad (2)$$

VI. Conclusion

This paper describes monitoring and learning of plant growth and health for effective supply of water, nutrients and pesticides in large scale plantations. As we are described in detail in the main content all the technologies used in this project are selected to mark the cost effectiveness and efficient. The main objective of this projects is to take the level of human intervention into a zero level. It is possible to automate the supplies with the existing technologies but still it requires some human labor for the decision making part. That is why we specially focus on automating that decision making part. This project is titled as it for large scale gardens it has the capability of implementing in any scale. Here in the first implementation tomato is supposed to be used .Therefore water supply is not depend on the stage of the tomato plant as it required same amount of water throughout its life span. However fertilizing is varied according to the stages. Likewise if this concept is going to be implemented into another kind of plant the decision taking part may be varied a bit. This is the best solution for those who have the desire but not able to involve in planting as it requires a large portion of their daily schedule. We believe this technology is the best match for their greenfinger.

Acknowledgment

This paper and the research behind it would not have been possible without the exceptional support of our supervisor, Dr. Chamitha de Alwis. His enthusiasm, knowledge and exacting attention to detail have been an inspiration and kept our work on track. We acknowledge the contribution of Dr.Chamil Bandara, Senior Engineer, NGN-operations of Mobitel (Pvt) Ltd. towards the development of this concept. We are also grateful for the insightful comments offered by the anonymous peer reviewers at Books & Texts. The generosity and expertise of one and all have improved this study in innumerable ways and saved us from many errors; those that inevitably remain are entirely our own responsibility.

References

[1] Paparao Nalajala, D. Hemanth Kumar, P. Ramesh and Bhavana Godavarthi, 2017. Design and Implementation of Modern Automated Real Time Monitoring System for Agriculture using Internet of Things (IoT). Journal of Engineering and Applied Sciences, 12: 9389-9393.

[2] M.K.Gayatri, J.Jayasakthi, Dr.G.S.Anandhamala, "Giving Smart Agriculture Solutions to Farmers for Better Yielding Using IoT", IEEE International Conference on Technological Innovations in ICT for Agriculture and Rural

[3] Nikesh Gondchawar, Dr. R. Complexion.Kawitkar, "iot based agriculture", all-embracing almanac consisting of contemporary analysis smart minicomputer additionally conversation planning (ijarcce), vol.5, affair 6, June 2016. Overall Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169 Volume: 5 Issue: 2 177 – 181

[4] Joaquín Gutiérrez, Juan Francisco Villa-Medina, Alejandra Nieto-Garibay, and Miguel Ángel PortaGándara, "Computerized Irrigation System Using a Wireless Sensor Network and GPRS Module", IEEE Transactions on Instrumentation and Measurements, 0018-9456,2013

[5] K. Lakshmisudha, Swathi Hegde, Neha Cole, Shruti Iyer, " good particularity most stationed cultivation spinning sensors", state-of-the-art weekly going from microcomputer applications (0975-8887), number 146-no.11, july 2011

[6] Lustiness. R. Nandurkar, Slant. R. Thool, R. Tumor. Thool, "plan together with situation coming from rigor horticulture technique executing trans-missions sensor network", IEEE world consultation toward telemechanics, regulate, intensity also wiring (aces), 2014. Development (TIAR 2015).

[7] Arampatzis, T.; Lygeros, J.; Manesis, S. A survey of applications of wireless sensors and Wireless Sensor Networks. In 2005 IEEE International Symposium on Intelligent Control & 13th Mediterranean Conference on Control and Automation. Limassol, Cyprus, 2005, 1-2, 719-724

[8] Orazio Mirabella and Michele Brischetto, 2011. “A Hybrid Wired/Wireless Networking Infrastructure for Greenhouse Management”, IEEE transactions on instrumentation and measurement, vol. 60, no. 2, pp 398-407.

[9] Ishak, Syafiqah; Fazalul Rahiman, Mohd Hafiz; Mohd Kanafiah, Siti Leaf disease classification using artificial neural network.

[10] Ramesh Maniyath, Shima;V, Vinod;M, Niveditha;R, Pooja;N, Prasad;N, Shashank;Ram, Hebbar Plant Disease Detection Using Machine Learning 2018 International Conference on Design Innovations for 3Cs Compute Communicate Control (ICDI3C)

[11] Beleites, Claudia;Neugebauer, Ute;Bocklitz, Thomas;Krafft, Christoph;Popp, Jürgen - Sample Size Planning for Classification Models, 10.1016/j.aca.2012.11.007

[12] N. Kotamaki and S. Thessler and J. Koskiaho and A. O. Hannukkala and H. Huitu and T. Huttula and J. Havento and M. Jarvenpaa(2009). “Wireless in-situ sensor network for agriculture and water monitoring on a river basin scale in Southern Finland: evaluation from a data users perspective”. Sensors 4, 9: 2862-2883. doi:10.3390/s90402862 2009.

[13] Liu, H.; Meng, Z.; Cui, S. A wireless sensor network prototype for environmental monitoring in greenhouses. International Conference on Wireless Communications, Networking and Mobile Computing (WiCom 2007), Shangai, China; 21-25 September 2007.

[14] Baker, N. ZigBee and bluetooth - Strengths and weaknesses for industrial applications. Comput. Control. Eng. 2005, 16, 20-25.

[15] IEEE, Wireless medium access control (MAC) and physical layer (PHY) specifications for lowrate wireless personal area networks (LR-WPANs). In The Institute of Electrical and Electronics Engineers Inc.: New York, NY, USA, 2003.

[16] Jayamala K. Patil, Raj Kumar, “Advances In Image Processing For Detection of Plant Diseases” JABAR, vol. 2(2), pp. 135-141, June-2011.

[17] Stephen Gang Wu, Forrest Sheng Bao, Eric You Xu, Yu – Xuan Wang Yi – Fan Chang [2007] A Leaf Recognition Algorithm for Plant Classification Using Probabilistic Neural Network, IEEE 7th International Symposium on Signal Processing and Information Technology.

[18] Prof.Sanjay B. Dhaygude, Mr.Nitin P. Kumbhar, Agricultural plant Leaf Disease Detection Using Image Processing, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering , S & S Publication vol. 2, Issue 1, pp: 599-602, 2013.

[19] V. Pooja, R. Das, and V. Kanchana, “Identification of plant leaf diseases using image processing techniques,” in *Proceedings of the 2017 IEEE Technological Innovations in ICT for Agriculture and Rural Development (TIAR)*, pp. 130–133, Chennai, April 2017.

[20] F. Y. Shih and S. Cheng, “Automatic seeded region growing for color image segmentation,” *Image and Vision Computing*, vol. 23, no. 10, pp. 877–886, 2005.