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Automated Plant Nursery and Disease Detection System for Green Houses Capsicum Plant

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***Abstract* - Capsicum has become more economically viable and has the potential to cure various diseases, so it is appropriate to grow it in greenhouses for maximum yield, but our research showed that farmers in Sri Lanka lack extensive knowledge about growing capsicum crops in greenhouses. This paper gives a simulation of an IoT-based resolve to the identified research problem which utilizes machine learning and image processing to provide analyzed data to greenhouse owners via a web application. This study focuses on how environmental changes and diseases associated with the capsicum crop impact the greenhouse production process. Detecting changes in temperature, light, and soil moisture with precise real-time data using smart technology is critical for disease detection and product quality detection. This is due to Sri Lankan farmers' lack of comprehension regarding choosing an appropriate variety, fertilizing, watering, harvesting, and properly detecting a disease. Because crops can be produced under controlled conditions, greenhouse cultivation is known as safe cultivation.**

Keywords: Machine learning, Image processing, Support Vector Mashine, Internet of Things, You Look Only Once Algorithm.

I. INTRODUCTION

Greenhouses are built to protect plants from bad weather and provide the right temperature throughout the year. They can also be used to conserve water in limited areas. Capsicum plants require a stable and suitable environment to produce significant crop production [1]. A greenhouse is a structure with a glass roof and glass walls. Plants such as tomatoes and capsicum are grown in greenhouses. A greenhouse maintains a comfortable temperature even in the cold. Gases in the atmosphere like carbon dioxide store heat like a greenhouse glass roof [2]. Plant growth is enhanced by warmth and moisture. Plants need moisture, warmth and light to stay healthy. The growing environment is maintained by a greenhouse that reflects the air temperature and protects the plants from extreme cold.

Growing plants or vegetables in a building with walls and a roof made mostly of transparent materials is called greenhouse farming. The inside of a greenhouse that receives direct sunlight is significantly warmer than the outside, protecting plants from freezing temperatures. Greenhouse production can be done throughout the year and earn a steady income. A greenhouse can be used for many reasons throughout the year. Vegetable crops, vegetable grafting for vegetable growers, and ornamental and flower production are all possibilities [3].

Currently, it will be more efficient if we construct a technology-enabled greenhouse to produce a consumer-friendly crop, which we focus on through this research.

This smart greenhouse monitoring system will be useful for greenhouse owners, it combines the functionality of the image capture system with live data to identify the crop position and distance through a web application, includes temperature, humidity, soil moisture and a light intensity maintenance system. Automatic and manually controllable cooling fans, water pump devices and lights using mobile application/ web application. This includes two devices a main device based on NodeMCU, and a sub device based with Arduino uno board which gives the capability of portability soil moisture reader.

II. RELATED WORK / LITERATURE REVIEW

Urban farming using IoT has been discussed through many specific areas to achieve the required success of plant growth and the efficiency. This research has gone through several past work and have considered to develop some features that would be important to the future users. Green houses need to be monitored always. With a simple change of the environmental factors may cause loss of the entire harvest. So to check the environmental factors such as soil moisture,

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humidity, and temperature there was an Invention of an IoT based monitoring system [4]. It was developed using the Raspberry Pi board with a combination of the DHT11 sensor and a capacitive soil moisture sensor. There was also a study which led to another environmental factor, light intensity. They have managed to get the light intensity using a BH1750 sensor and soil moisture using FC-28 sensor, DHT11 humidity temperature sensor along with the Raspberry Pi board. It was also automated as an additional novelty [5]. Even though they have managed to get some sort of success the problem still appears in some ways. They couldn't check the soil moisture throughout the entire green house. The cost was a bit higher for the farmers to bearer. So to that we have done our study to solve those issues.

A study was conducted to develop and evaluate a real-time phenotyping system using an image processing approach to measure plant height and width under field conditions. Image processing algorithm was developed and compiled in OpenCV and python language using PyCharm as IDE. The developed system was able to capture a valid image of the chili plant under field conditions and accurately estimate plant height and width with an RMSE in the range of 0.30–0.60 cm. Height and width measured by the proposed image processing algorithm were strongly correlated with manually measured values (R2=0.80-0.95). [6] If we use image processing to monitor the height, it is difficult to get an accurate output because the results may depend on the distance from which the photo is taken. So in our study, we have used a linear regression model to get accurate data. We have used image processing and the inceptionv3 model to monitor nutrient deficiency for plant growth. There is also a feature where the user can generate a report of plants with perfect growth.

Plant diseases affect the quality and the growth of a plant. The plant needs to be healthy to get the maximum crops of it. If a plant gets affected from a disease, some symptoms which is different from each disease will appear on the plant leaves. [7] This study was conducted to detect diseases of plants using image processing techniques like Image Acquisition, pre-processing, feature extraction and convolutional neural network (CNN) algorithm. It also uses contrast limited adaptive histogram equalization (CLAHE) on the datasets in the disease identification process. It compares the images with the dataset after resizing. After it will display the results. It was used to capture tomato leaves. In the study [8] they have also used CNN algorithm for illustration analysis of plant diseases they have developed disease detection for 7 plants with the help of a dataset containing 8,685 images. After going through them and some other several papers we developed a system which includes disease identification and to display the instructions along with the disease to remove and control them, medical suggestions with the dose required separately and the factors that caused the plants to get infected.

A study was done using size and the color of crops.[9] They have used 4 features to classify them, 4 different classes according to the maturity level and 3 different classes as per size. They have used nearest neighbor technique and linear regression. Linear regression was used to predict the maturity level of this study. There was also a study done to estimate the maturity of a plant using artificial vision system for ripeness assessment and quality control of the plant.[10] The method used evaluates, ripeness levels based on the colors and shapes allowing the farmers to harvest at the right time. The harvest quality measurement component of this study has significant possibilities in improving capsicum crop farming methods.

III. METHODOLOGY

A) Overview

In furtherance of developing an Iot-based microclimate control system, this study suggests a mobile-responsive web application for learning about automated greenhouses, capturing images of capsicum plant leaves, detecting diseases, monitoring nutritional status, and measuring harvest quality. Using methods (ML Models), all the leaves and capsicum fruits were individually detected and categorized as healthy or unhealthy (suspect). Crop segmentation is used to isolate questionable leaves, which are then passed to Convolutional Neural Network (CNN) models for precise disease classification and differentiation. The system identifies and categorizes diseases and assigns a detection confidence score. Users can obtain the necessary guidance and assistance from agricultural specialists if the discovered diseases or pests have low-reliability scores. The output of ML models can be further validated by consulting with industry professionals.

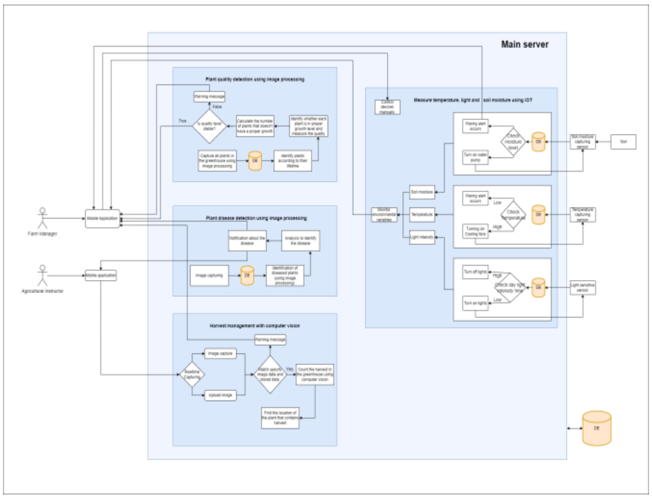

Figure 1: System Overview

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B) Harvest quality measurement system

Computer vision yield identification this module determines a greenhouse's yield by using computer vision and machine learning techniques, and the harvest quality was in the previous 15 days. And Filters for the chart's 30 day, 3 month, and 6 month periods are available. The strategy makes use of data analysis, machine learning techniques, and computer vision technologies. Users take a picture with the camera, which is then processed using You Look Only Once Algorithm (YOLO) version 5 ML Modal, which measures the form and color of the capsicum fruits and divides them into several categories according to their quality. Based on the quantity examined, the yield count is sent. Lastly, compile the information from each month and forecast the yield for the subsequent month. Computer vision yield identification this module uses computer vision and machine learning to determine a greenhouse's yield. Its functionality is based on an unsupervised learning model.

Figure 2: Sample Capsicum Fruit Images

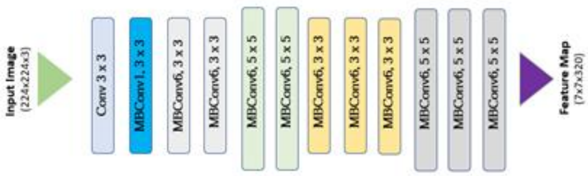

Figure 3: Efficient Net Architecture

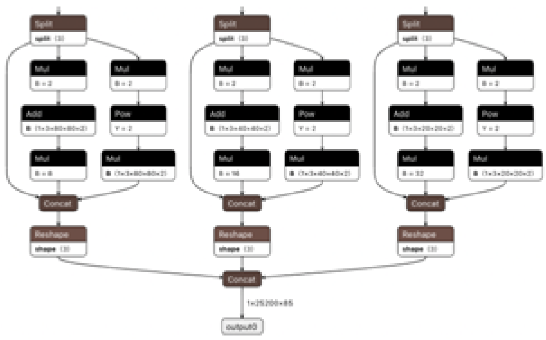

Figure 4: The detection head of YOLOv5

C) IoT based microclimate control system

Three distinct sensors that were programmed with Arduino IDE technology were installed as part of an IoT smart monitoring system to record indoor temperature, humidity, soil moisture, and light intensity. This sensor data is transferred to a live database of Firebase each time it is read.

We have utilized "DHT11" sensor to read temperature and humidity, "Capacitive Soil Moisture sensor" for soil moisture and a "BH1750" sensor to collect data on light intensity. We also used a " BH1750 " sensor with the assistance of an esp8266 module to collect data on light intensity. This device system of two devices, main device based on the NodeMCU utilizing the DHT11 sensor and the BH1750 sensor with a display mounted which displays the data captured. The sub device is based on the Arduino Uno board which contains the soil moisture sensor. This device can be connected to six soil moisture sensors at the same time with radio frequency within an area of 800m covered. It gets the average of the soil moisture read through the sensors. It identifies the sensors by the separate IDs provided, providing a more accurate value. Both these devices are connected using "nRF24L01" radio frequency modules with antennas. The collected data is used to control the cooling system, lighting system, and irrigation system, both manually and automatically. Additionally, security warnings get there at critical moments, making it simple to act and quickly lower risk.

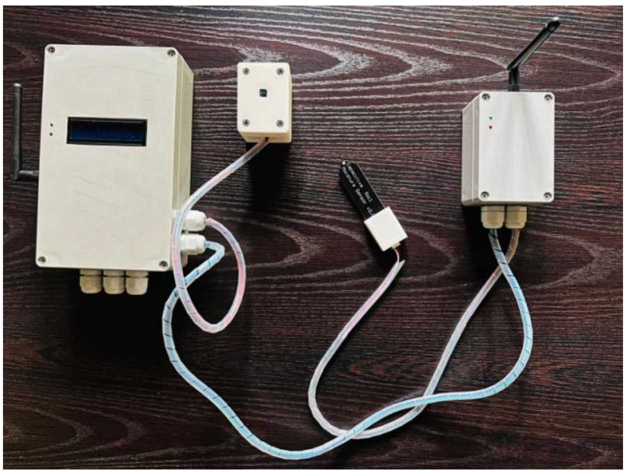

Figure 5: IoT device

D) Plant quality and growth monitoring system

This work considers the quality of capsicum crop. To identify whether the crop is a quality product, it is necessary to check whether the crop has grown properly. The system will detect the proper growth of the crops by the captured images of the capsicum leaves and the height of the crop. Then, using image processing technology and an SVM model, if there is a

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lack of nutrients required for proper growth in the leaves, they are identified and the factors that caused it are eliminated and controlled, and crops that do not have proper growth are identified. And by using the logistic regression algorithm, it is determined whether there is proper growth according to the height of the crop. The system then calculates the percentage of crops that are correctly planted. A notification is then sent to the farm manager by generating a report telling the percentage of crops grown properly.

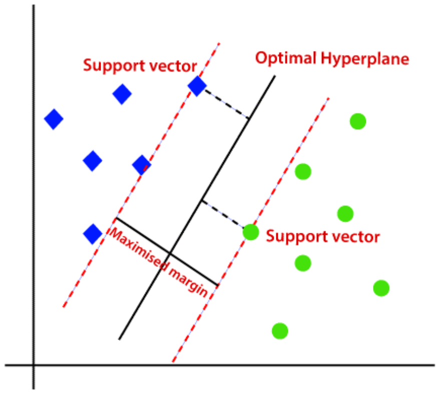

Figure 6: Support Vector Algorithm

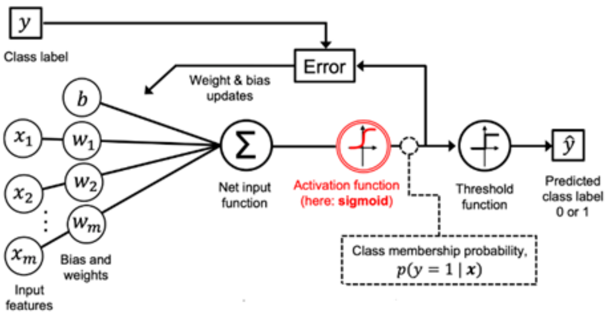

Figure 7: logistic regression algorithm

E) Plant disease detection system

Identification of the disease system that has infected the crop from captured foliage is considered here. Images of recently harvested Capsicum leaves were used to train machine learning (ML) models. Then, using data classification for SVM model. Upper surface images of Capsicum leaves were taken for mosaic virus disease detection. To avoid sample similarity, images were captured in different natural environments. With the help of the greenhouse owner and agricultural experts, leaf samples were taken. The training images range from 80% to 20% complete and the validation images from 10% to 20%. After training, a new collection of images was added to test the model. Data set pre-processing techniques were used to improve accuracy and simplify it. Due to their different sizes and color formats, the generated images were resized to the same dimensions (256 x 256) and converted from BGR to RGB for color. Identification of plant diseases is considered here. The system detects the disease that has infected the crop from captured foliage. Then a notification is sent to the farm manager with the instructions related to the disease and the amount of medicine required for the disease. Then a notification is sent to the farm manager with the instructions related to the disease and the amount of medicine required for the disease.

Figure 8: Sample Capsicum Disease Leaf Images

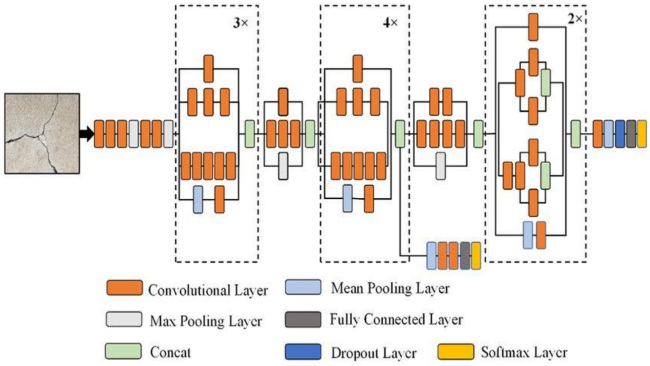

Figure 9: The architecture of Inception-V3 model

IV. RESULTS AND DISCUSSION

The basic purpose of this system is to prepare an easy work arrangement to get more productivity with less human labor contribution, with proper growth and free from diseases.

Soil moisture is measured using a portable soil moisture sensor in the IOT based microclimate control system. Here, up to six soil moisture sensors can be fixed within 800m from one place to another in the green house. Then the average of all of them as well as the separate readings of the sensors is displayed as soil moisture. Therefore, a more accurate value can be reached. Also, since specific environmental conditions are required for the growth of capsicum plants, it can be controlled both automatically and manually. Also, security alerts come in critical situations, so it is easy to act, so the risk can be reduced quickly.

In the growth monitoring system, the plants in the greenhouse are separated into groups according to how they have grown, and when one plant is taken from each group and their height is manually measured and entered into the system, the height that should be according to age is considered using a linear regression model. Then the growth of the plant is

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shown as a percentage. And to see if there is a lack of nutrients needed for the growth of the capsicum plant, using image processing technology and the SVM model, the nutrients contained in the plant leaves are identified and if there is a lack of them, it will be informed about it. Also can generate a report about plants that have successfully grown.

In the disease detection method, photos of diseased capsicum leaves in the greenhouse are taken and uploaded to the system, and then using image processing technology and SVM model, the disease in the leaves is detected and the factors that caused it are removed and controlled. This helps the farmers to take timely preventive measures and prevent the spread of the disease. Disease-free crops yield higher yields. It means farmers can get a better return on their investment. And because the dosage of medicine required to cure those diseases is suggested separately, it is easy to control the diseases. By using this system, farmers can reduce the cost of disease testing and labor costs. Due to this, farmers can get more profit.

In the harvest quality measurement method, photographs of the crop inside the greenhouse are taken and uploaded to the system, and yield measurements are made using image processing technology and the Yolo model. And a report can be generated about the quality and quantity of the harvest. This technology allows farmers to monitor the growth of their crops and decide when to harvest and how to care for them more intelligently. By improving the quality and yield of their crops, farmers can increase their profits while improving the sustainability of operations.

V. CONCLUSION

The Automated Plant Nursery and Disease Detection System for Greenhouse Capsicum Plants aims to improve plant culture and management. The system includes Harvest Quality Measurement, Plant Disease Detection, Plant Quality and Growth Detection, and an IoT-based microclimate control system. The Harvest Quality Measurement function analyzes fruit identification, shape, color, and yield to track harvest progress and identify areas for improvement. The Plant Quality and Growth Detection function assesses crop growth quality, aiding in decision making and resource allocation. In disease detection, images of infected capsicum leaves are captured and then using image processing technology and ML model, the disease in the leaves is detected and control is given with the necessary advice and medication. The IoT-based automated microclimate management system monitors temperature, humidity, soil moisture, and light intensity, enabling manual and automatic management of microclimate parameters.

VI. FUTURE WORK

While our research effort has made major advances in automating plant nurseries and disease detection for capsicum plants, there are various areas for further enhancements and study.

Improved Disease Detection: By increasing the range of diseases identified and creating more powerful machine learning algorithms, the system's accuracy and early detection capabilities may be improved. Additional environmental elements, such as air circulation and CO2 levels, can help give a more comprehensive disease monitoring solution.

Advanced Growth Monitoring: Investigating advanced computer vision techniques such as leaf segmentation and plant feature extraction can improve growth monitoring accuracy. Machine learning models can help the system recognize and analyze complicated growth patterns, allowing for more precise crop evaluation.

Predictive Analytics: Creating prediction models based on previous data can help farmers make better decisions. Predictive analytics may give insights into ideal planting schedules, predicted yields, and disease outbreak probability, allowing for active agricultural production initiatives.

Improving accuracy of the overall IoT device: Improve the to get highly accurate data from the sensors and improve the interface of the mobile application.

We can continue to improve the field of automated plant nurseries and disease detection systems by pursuing these future efforts, equipping farmers with efficient and sustainable agricultural practices.

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