Evolution in Electrical and Electronic Engineering Vol. 2 No. 2 (2021) 989-998

EEEE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/eeee
e-ISSN : 2756-8458

The Crop Disease Detection on Vertical Farming using Image Processing

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DOI: https://doi.org/10.30880/eeee.2021.02.02.117
Received 13 February 2021; Accepted 17 October 2021; Available online 30 October 2021

Abstract: Presently, the indoor farming technology developed to accommodate the food demand. But, there still having food loss mainly due to crop infected by disease, which reflexively reduces the production rate. The main challenge is to improve the crop disease control and increases the crop quality and quantity in indoor farming mostly in vertical structure. The purpose of this research is to build crop disease detection system for vertical farming using image processing. Image processing method is one of computer vision technology use to identify and process the object in image. Hence, the image processing method is applied for the plant disease's detection. Disease detection involves the steps like image acquisition, image pre-processing, image segmentation, feature extraction and disease classification. Initially, the input images were retrieved from vertical farming using digital camera. Then, in image segmentation steps, k-mean clustering used to predict the infected area of leaves. K-mean clustering is a color based segmentation model to segment the infected region and placing it to its relevant classes. The feature of disease spot was extracted based on its texture and colour. Multi support vector machine technique (MultiSVM) were used to categorize feature and finally, classify the disease. Experimental analyses were done on four samples of Choy Sum plant to detect disease name, percentage area of infection and accuracy. Among the four plants tested, plant number 4 show the highest accuracy of downy mildew disease with 98.3871% with area of infection 11.0154% while the plant number 1 show the highest accuracy of healthy leaf also with 98.3871%. Lastly, this project successfully builds the GUI for whole disease detection system.

Keywords: Crop Disease Detection, Vertical Farming, Image Processing

1. Introduction

Every single day, the world become crowded with human and human population estimated by year 2050 is 9.8 Billion [1]. Also due to urbanization and industrial development, world is losing arable land every day. Scientists say that over the last 40 years, Earth has lost a third of its arable lands.

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The decreasing arable lands along with increasing human population by 30.67% from current population, people will face with one of the greatest challenges which is supplying sufficient food in future. Then, people tend to solve the issue by inventing the indoor farming. This idea practically decrease the space used for farm and overcome food crisis in future

Comparing to growing vegetable or others food in single surface level like field, vertical farming method producing the food in vertical inclined surface or staked rows and its look like a rack structurer. Vertical farming assisted with Controlled Environment Agriculture (CEA) technology in humidity, light, temperature, and gases control [2]. Although occupied with CEA technology, vertical farming still operates with human labour in installing, planting, control, and harvesting process.

The main goal of vertical farming is maximizing the crop quantity and quality, the crop nutrition in equivalent with field farming output. Then, diseases control is very important to achieve the goal. Hence, a crop disease detection system should be developing and implement to make vertical farming operate more efficient. The crop disease detection system would monitor and analyse the condition of crop in every row of vertical farming without using scissor lift and give the feedback faster and accurate. Image processing method can be applying in this system to recognize the abnormal condition of the crop. In this project, the prototype is developed. The aim of the prototype system can recognize the disease of crop through camera by using image processing method.

2. Methodology

2.1 System Design

The crop disease detection system consists of software and hardware implementation part show in Figure 1. The hardware part focus on leaves image capturing form vertical farming. Arducam Camera used attach with camera slider and interface with Arduino Uno for controlling and capturing images. The slider moving horizontally by stepper motor controlled by analog joystick. For software part, the system use Arducam Host software to monitor camera position, command image capture and save the image. The saved image will feed to MATLAB software for process of disease detection.

The process start with image acquisition, pre-processing, segmentation, feature extraction and image classification. The classification step needs database training data to test and compare input data with training data to obtain results. Database stores the training data of only healthy leaf, powdery mildew disease and downy mildew disease and use those feature to predict future disease detection. Table 1 explain detail system design diagram and Figure 2 shows the flow chart of image processing using MATLAB. In this project, the crop disease detection system will be classifying only healthy leaf, powdery mildew disease and downy mildew disease.

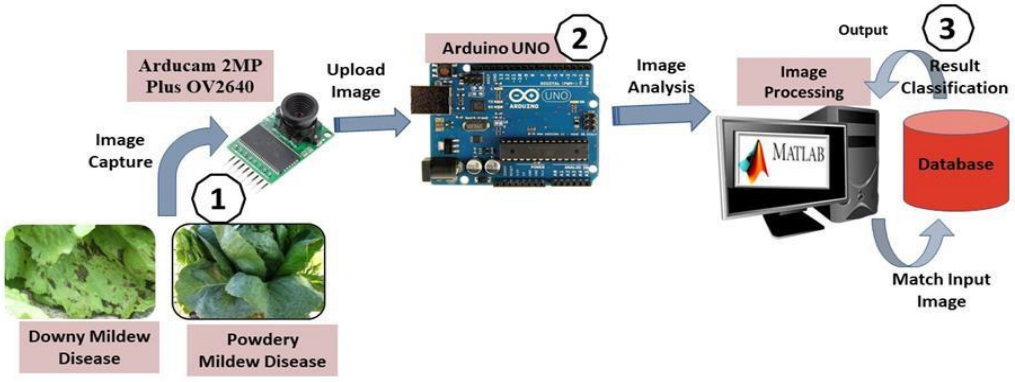


Figure 1: System design diagram

Table 1: Explanation of the system design diagram

Label	Name of label	Explanation
1	Arducam 2MP Plus OV2640	The camera use to capture image of plant leaf on vertical farming
2	Arduino UNO	Arduino Uno as microcontroller in this project interface with Arducam Camera and control stepper motor to move the camera position horizontal along the vertical farming.
3	MATLAB Image Processing Program	Process the image input for image pre-processing, segmentation, feature extraction and image classification.

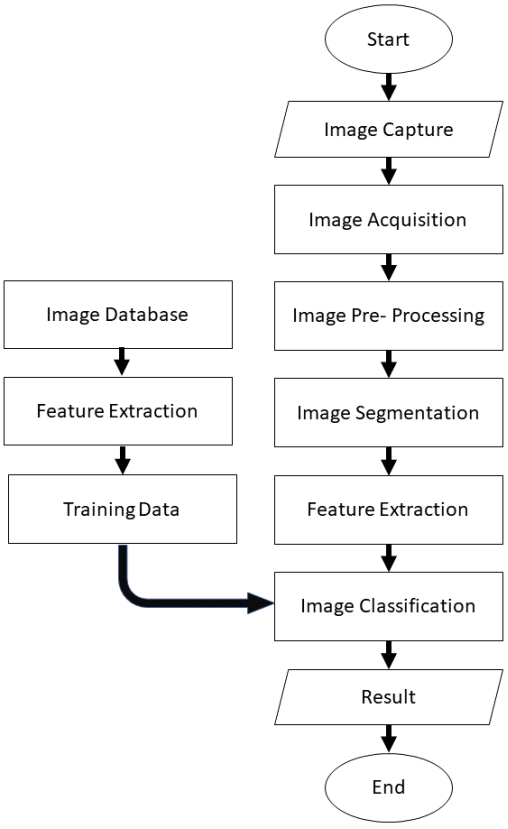


Figure 2: Image processing Flow Chart

2.2 Circuit Design and Connection

The software that used for designing Figure 3 is Fritzing. In this project, Arduino Uno used as microcontroller. Analog Joystick connected as input to locate the camera by control the stepper motor rotation. Then, the camera will capture the image below it and sent to computer via USB connection. Easy Driver provide flexibility, control over and power up the stepper motor. The Easy drive need a 6V to 30V supply to operate and provide regulated voltage to motor. The easy driver is connected to Arduino Uno to precise the motor control.

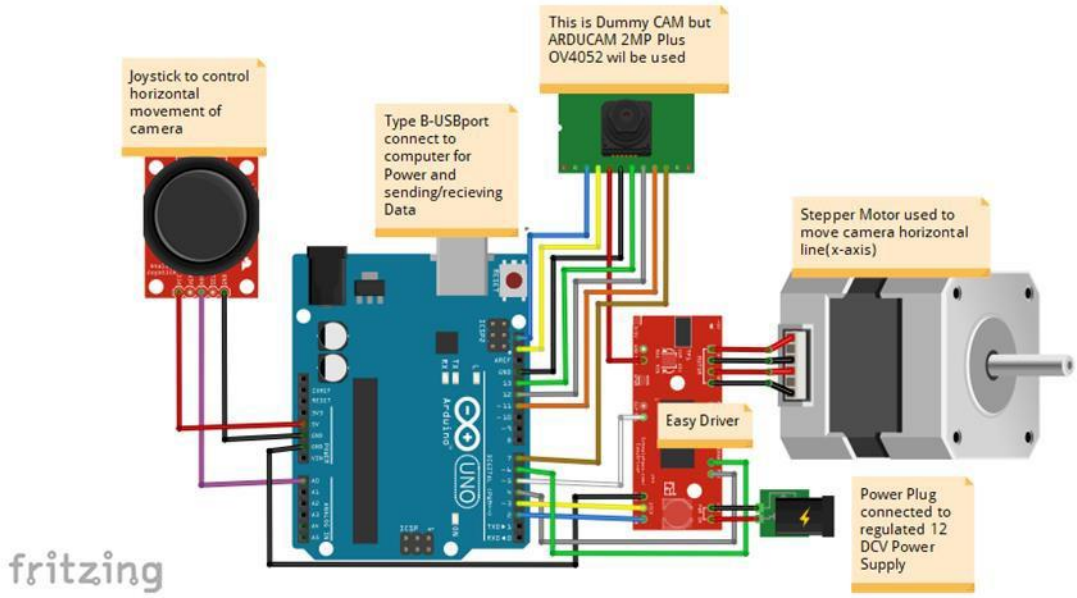


Figure 3: The circuit diagram of camera system on vetical farming

3. Results and Discussion

3.1 Prototype design for the system

Figure 4 shows final product of vertical farming prototype used in this project. The final prototype attached with camera module and its controller. The controller function to move camera horizontally above the plant. LED T8 use AC supply to turn on for 16 hours. The LED T8 provide full spectrum of grow light.

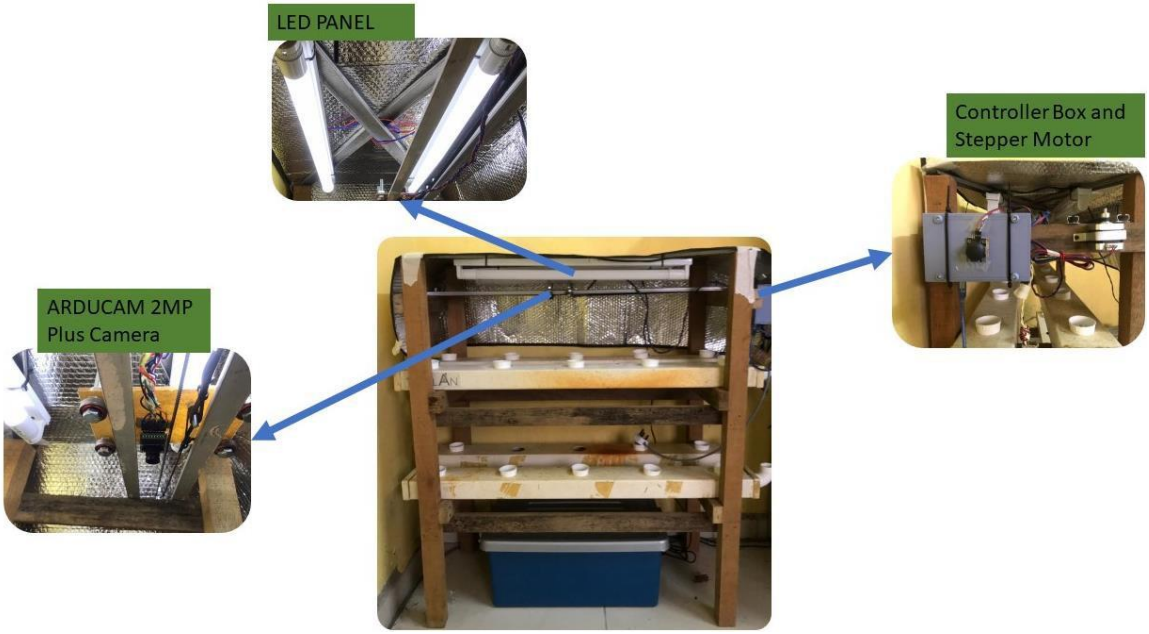


Figure 4: Final Vertical Farming Prototype

3.2 MATLAB GUI development for disease detection system

In by designing GUI, the plant disease detection program seems easier to use, user friendly and result directly displayed. From Figure 5, the GUI only have five pushbuttons to function. First, insert image pushbutton, function to select input image from local folder to be process. The input image will have showed below the button. Next, enhance contrast pushbutton, apply image enhancement contrast to image input. The output will become clearer and focus on disease region.

Then, as segmentation image pushbutton pressed, the input image divides into three cluster based on colour segmentation. A window and dialog box will pop up required user to respond by select the cluster contain disease region. As cluster choice selected, all the extracted feature result will display on GUI. Next, user required to press the pushbutton classification result to reveal the disease name result. Besides that, affected region calculated in percentage and displayed on GUI. Lastly, to obtain the accuracy, user has to press accuracy pushbutton and accuracy will display in the box below pushbutton.

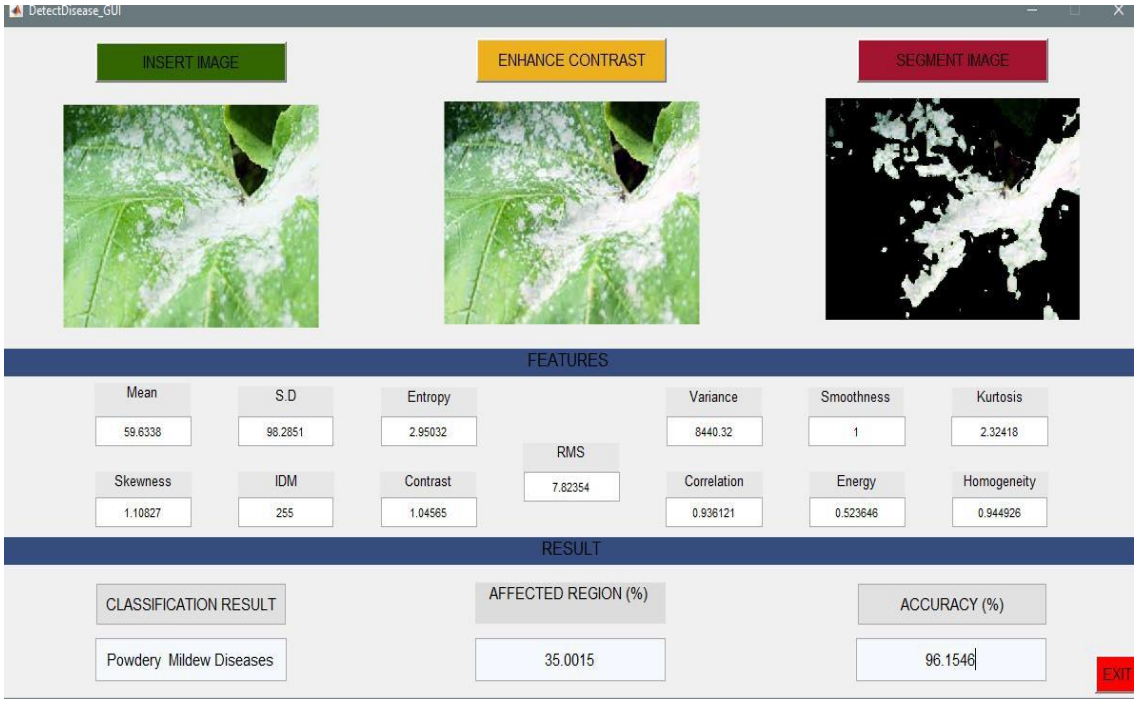


Figure 5: Example of MATLAB GUI for disease detection system with result

3.3 Results

For testing the detection system, the subject test needed. Choy sum plant used as subject test to observe the result. Choy sum is vegetable plant have possibility to effected with powdery and downy mildew disease. About four Choy Sum plant planted on vertical farming. The plants then exposed to disease, two plants exposed to powdery mildew and others 2 two exposed to downy mildew disease. Table 1, 2, 3, and 4 are the result of plant 1, 2, 3, and 4 respectively. The result obtain were disease name detected, area of infection and accuracy of detection.

- **Plant number 1**

For plant number 1, this plant supposed to affected to powdery mildew disease. The white spot should slowly grow on leaf but it turns to the plant remain healthy. From the Table 1, all the input image from day 1 to 5 of plant 1 has no disease detected on leaf. By then, no area of infection calculated. The accuracies in detection healthy leaf for day 1 to 5 which are 96.7745%, 96.7742%, 96.7742%, 98.3871% and 98.3871% respectively. The accuracy value increased day by day as input image shown no abnormal on leaf. The plant number 1 leaf grow all green and healthy.\

Table 1: Result Plant number 1

	Original Image	Enhancement Image	Segment Image	Disease Detect	Area of infection (%)	Accuracy (%)
Day 1				Healthy Leaf	None	95.1613
Day 2				Healthy Leaf	None	96.7742
Day 3				Healthy Leaf	None	96.7745
Day 4				Healthy Leaf	None	98.3871
Day 5				Healthy Leaf	None	98.3871

- **Plant number 2**

The Table 2 show plant number 2 development. This plant unpredictable had affect by downy mildew disease, not powdery mildew disease as expected. On day 1, the plant result as healthy leaf and no disease detect. Then, a small brown spot spotted on leaf on day 2 and enlarge its area until day 5. The input image from day 2 until day 5 detected as downy mildew disease. The brown spot is one of characteristic of downy mildew disease. As disease detected, the affected areas are calculated. The area affected on day 2 is 15.0123%. The area quickly grows by 25.0031% on next day. Then, disease area starts grow slowly. On ROI input image number day 5, lower left leaf seems more likely also affect by disease.

Table 2: Result Plant number 2

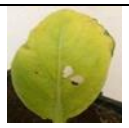
	Original Image	Enhancement Image	Segment Image	Disease Detect	Area of infection (%)	Accuracy (%)
Day 1				Healthy Leaf	None	96.7742
Day 2				Downy Mildew Disease	15.0123	95.1613
Day 3				Downy Mildew Disease	25.0031	96.7742
Day 4				Downy Mildew Disease	28.911	98.3871
Day 5				Downy Mildew Disease	29.435	98.3871

- **Plant number 3**

Plant number 3 show on Table 3, the leaf already yellowish colour in upper part. The leaf has sign of affected by downy mildew disease. A small brown spot start to grow from edge of plant leaf. Start on day 3, the leaf fully turns to yellow colour. The ROI area covered all over the leaf area on day 5. For disease detection, image processing program recognize the downy mildew disease from day 1. Area of infection also expand to day 3. Then start input image day 4, the amount of area drops due to leaf shape bend curve downward. On the other hand, the camera unable to capture fully area of leaf. By then, the brown spot can't be analyze cause accuracy decreases.

The accuracy drops from 96.7742% to 92.3871%. The area of infection become wider days by days but at day 4 the area of infection decrease by 11.9809%. The reason is because the leaf shrink and area of infection become smaller. To conclude, the plant number 3 successfully affected by downy mildew disease.

Table 3: Result Plant number 3

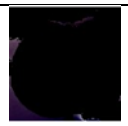
	Original Image	Enhancement Image	ROI	Disease Detect	Area of infection (%)	Accuracy (%)
Day 1				Downy Mildew Disease	36.1931	95.1613
Day 2				Downy Mildew Disease	37.9051	95.1613
Day 3				Downy Mildew Disease	56.5012	98.2
Day 4				Downy Mildew Disease	44.5203	96.7742
Day 5				Downy Mildew Disease	45.7557	92.3871

- **Plant number 4**

For plant number 4, the leaf affected by downy mildew disease as show on Table 4. The plant leaf quickly shows the symptom of downy mildew disease. After that, downy mildew disease does not spread to lower part of leaf and constantly at upper left part of leaf. The brown disease spot slightly turns to dark brown day after day. Image segmentation result less accurate although ROI contain brown spot but ROI include the image outside of leaf area. The factor affected by colour of image outside of leaf area same pixel value with brown leaf.

The area of infection in this case is less than 50%. The area affection slowly decreases from 35.8539 on day 1 to 11.0154% on day 5 as the system calculated on brown spot area only. For accuracy, disease detection system obtains result accuracy above 95%. To conclude, the plant 4 successfully affected by downy mildew disease.

Table 4: Result Plant number 4

	Original Image	Enhancement Image	Segment Image	Disease Detect	Area of infection (%)	Accuracy (%)
Day 1				Downy Mildew Disease	35.8539	96.7742
Day 2				Downy Mildew Disease	25.2911	95.1613
Day 3				Downy Mildew Disease	13.1668	96.7742
Day 4				Downy Mildew Disease	12.4903	96.7742
Day 5				Downy Mildew Disease	11.0154	98.3871

4. Conclusions and Future Works

In conclusion, plant disease detection using image processing can be done by using MATLAB software. Vertical farming most likely suitable in implement the disease detection by image processing as vertical farming very optimize in food production in big city and crop disease control very important aspect. The project starts with obtain input image form the plant. Arducam 2MP plus is controlled by Arduino Uno captured images of crop from vertical farm. The image captured must be pre-processing and do enchantment to remove noise and improve its quality.

For image segmentation, the project use k-mean clustering. The idea is use colour base to cluster the image into three cluster. Among the cluster produce only one of them focus the region of interest which is disease spot. K- mean cluster successful to produce desire output for next image feature extraction. Next, 13 feature extraction of ROI including from GLCM feature. The feature use to test with database training to classify the disease. Database training is done before the test of any input image start. Database training creating same step from image pre-processing until feature extraction. Then the feature was train by using MultiSVM technique and store into extension file. The file will load in main program when to test the input images. The GUI developed to simple the usage of disease detection project and more user friendly.

The result will obtain after finish the classification process. From plant number 1 and number2, it supposedly affected by powdery mildew disease, but the result show plant number 1 is remain healthy and plant number 2 is affected by downy mildew disease. Then, for plant number 3 and number 4, both plant successfully affected by downy mildew disease. Those all plant proven the functionality of disease detection system by image processing by detect the disease name, area of infection and accuracy. The highest accuracy recorded for healthy leaf is 98.3871% which is from plant number 1 on day 5. The input image shows leaf grows bigger and its colour turns to dark green. For downy mildew disease

detection, the highest accuracy result is also 98.3871%. The result recorded are from the plant number 2 and number 3 and both are images input from day 5. The overall results presented prove the crop disease detection system using image processing technique is efficient and successful.

For future work, this project can be update in many aspects. The performance measure result especially accuracy in disease detection can be increases by upgrading the training database. Variety of plant disease can be register into this project thus, expand the area of usage to different type of plant. When come to capturing the input image, the equipment such as camera resolution can be improving. Higher camera resolution produces less noise and clearer image output. Thus, the higher resolution input image will give the system more accurate output in feature extraction and disease classification. This project can turn into more user friendly, compatible and easy for daily use. This can be done by apply this methodology into internet of thing (IoT) application or into smartphone operating system (OS).

Acknowledgement

The authors would like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] Benke, Kurt, and Bruce Tomkins, "Future food-production systems: Vertical farming and controlled-environment agriculture," Sustainability: Science, Practice and Policy, 13.1, pp. 13-26, 2017.

[2] Muhammad Ikhwan Hanif bin Ismail, and Norashikin M. Thamrin, "IoT implementation for indoor vertical farming watering system," IEEE International Conference on Electrical, Electronics and System Engineering, 2017.