MULTIPLE VIEW IMAGE ACQUISITION RIG WITH IMAGE STITCHING CAPABILITY FOR 360 DEGREES ARTIFICIAL VIEWS OF CHILI PLANT USING EMBEDDED SYSTEM

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A report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Mechatronic Engineering with Honours

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this thesis entitled “MULTIPLE VIEW IMAGE ACQUISITION RIG WITH IMAGE STITCHING CAPABILITY FOR 360 DEGREES ARTIFICIAL VIEWS OF CHILI PLANT USING EMBEDDED SYSTEM is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : yong

Name : YONG WEN XIN

Date : 5/7/2021

APPROVAL

I hereby declare that I have checked this report entitled "MULTIPLE VIEW IMAGE ACQUISITION RIG WITH IMAGE STITCHING CAPABILITY FOR 360 DEGREES ARTIFICIAL VIEWS OF CHILI PLANT USING EMBEDDED SYSTEM" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Mechatronics Engineering with Honours.

Signature : ....

Supervisor Name : DR. NURDIANA BINTI NORDIN@MUSA

Date : 5/7/2021

DEDICATIONS

Specially dedicated to

My beloved father and mother

To every friends and mentors

Thanks for all the encouragement and support

ACKNOWLEDGEMENTS

First and foremost, I would like to express my deepest appreciate to my main project supervisor, Dr. Nurdiana Binti Nordin@Musa , for the useful comments, guidance and encouragement throughout this project. I would not have gone this far without her support and guidance in every way. In addition, I am very thankful to my she spent time in guiding me upon accomplish my final year project.

Furthermore, I would like to thank my family especially my beloved parents, Goh Yean Choo and Yong Chun Meng for their love, sincere support and care they have given to me all through my study journey.

Last but not least, an honorable mention goes to my lovely friends and course mates who helped and supported me both practically and mentally along completing this project.

ABSTRACT

Chili production is vital to Malaysian economy as the national consumption has steadily increased over the years. One of the way to increase productivity is to have an efficient pest control system. Damages on chili plants are difficult to monitor manually due to the vast amount of plants per plantation. Thus, a 360-degree monitoring system with image stitching is studied in this project to augment the pest control system in chili plantation. Images were taken from an embedded camera system and the image stitching algorithm is performed on those images to obtain the overall view of the plant. This project had implemented multiple shots with a camera and evaluated the performance of image stitching using universal image quality index by using mean squared error, MSE and strutural similarity index metric, SSIM. From the experiments conducted, the most accurate of stitched image scored MSE = 213.34 and SSIM = 0.8 in comparison to the original image.

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INTRODUCTION

1.1 Motivation

Chilli is known as worldwide most important crops which can produce from chilli powder, chilli sauce and so on. Chili fruits are important ingredients that are most used in all dishes as spice throughout the world, they are not only vegetable but also as medicine.

In Malaysia, chilli can acts as seasoning in many local cuisine such as sambal, chilli sauce, chilli powder, curry and so on. Therefore, chilli production has gained a huge market value. It ranks as the most popular fruit vegetable in this country. Based on FAMA statistical analysis, the estimated chilli production was 163,822 metric tonnes in year 2004.[1]However, local market needed 188,891 metric tonnes of chilli but production of chilli can not reach the target required so it caused 25,069 metric tonnes of chilli was being imported.[1]

Chilli production is hampered by pest and diseases. Most of the species of pests are white flies, trips, mites and aphids which caused huge losses in quality and quantity of chilli production.

Plant diseases are traditionally identified by visual inspection. It can be less accurate to the untrained and can be done only in limited areas. However, it will take less effort, less time if automatic detection technique is used. [1] By introducing an all-around monitoring of the plant using camera fitled to embedded controller that are mobile, the imspection of the damages may become routine and can contribute to improved production.

1.2 Problem Statements

The damages on the plant can be browning spots on the leaves, or the leaves becomes curled. However, brown spots can be visibly seen, curled leaves are not as easy. Moreover, the damages must be detected early so that it can be pruned as soon as possible to present more damages. Furthermore, damages on the plant leaves can occur everywhere, the farmers needed to search thoroughly for the damages on plant leaves which is time consuming. Therefore, a monitoring system is needed to be able to look at the whole area of crops of plant leaves.

1.3 Objectives

The objectives of this project are :

1. To design the 360 degree view monitoring system with image stitching that is suitable for monitoring chili plant's leaves.
2. To evaluate the performance of the image stitching algorithm for automated monitoring system in terms of accuracy of stitched images to help speed up the process based on mean squared error (MSE) and structural similarity index metric (SSIM).

1.4 Scope of the Project

This project reviewed only existing monitoring system on chili plants by using OpenCV. The method used in this project was multiple shots with a camera. For an example, by using a Raspberry Pi camera to take different shots with different angles which each picture must has overlapping area between each other from a single chili plant. This step was repeated to 15 chili plants in order to get the accuracy of stitched images by Raspberry Pi camera. Due to stitching limitations, this project monitored only on leaves of chili plant without the image of pot in terms of the sensor image area covered approximate to 3.68 x 2.76 mm and sensor resolution of images taken around 3280 x 2464 pixels. For this image stitching, only leaves of single plant had been monitored through OpenCV. Moreover, MSE (mean squared error) and SSIM (structural similarity index) value will be used to determine the performance of evaluation in this project.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of the Project

Infestation by insects bacterial and fungal diseases are routinely monitored in chili plantation. Example of infestation on chili leaves are shown on Figure 1.1 & 1.2 below.

Figure 2.1: Infected chili leaves

Figure 2.2: Infected chili leaves

2.2 Leaf Diseases Detection

Leaf diseases occurred not only on leaves but also occurred on stems and fruits of plant. Leaf diseases are the most common diseases founded on plants that usually affected with bacterial, fungi and viruses. Leaf diseases mostly infected by pest such as fruit borer, fruit fly, thrips, mites, white fly, aphids and cut worm. Infected chili plants will cause chili plant death which is huge impact to farmer’s chili production.

Dhaygude et. al. [2] described that there are 4 steps in developed processing scheme. Firstly for the input RGB image, this RGB is used for colour generation and transformed or converted image of RGB which created a colour transformation structure. HIS is used for colour descriptor.

Mrunalini et. al. [3] presented the technique to classify and identify the different disease on which plants are affected by diseases. This approach given is to determine the colour co-occurrence method for this feature set extraction. On this approach, neural networks are used on automatic detection of diseases in leaves. This approach gives an accurate detection on leaf’s diseases by putting less efforts in calculation.

Kulkarni et. al. [4] presented a methodology using artificial neural network (ANN). ANN used to process multiple image for accurately and early plant diseases detection. The proposed approach is based on ANN classifier. An ANN based classifier can assort different plant diseases which it uses the combination of features, colour and textures to recognize those plant’s diseases.

Sujatha et. al. [5] proposed the a method that used image processing to identify leaf diseases in MATHLAB. The proposed method’s step were loading image, contrast enhancement, converting RGB to HSI, extracting features an SVM to the infected leaves.

2.3 Methods of 360-degree view of images

Conventionally , 360-degree of images can be obtained by 2 methods. The first method is using one camera with multiple shots which means a camera must move to take several pictures. The other method is using multiple cameras with single shot simultaneously. By using the methods stated above, this research needed to stitch images taken from camera.

Figure 2.3 : 360-degree view of image

2.3.1 Multiple shots with a camera

Multiple shots with a camera mean by using a camera to shoot on the object with different angle and several shoots. In this method, several images are exposed normally and then stitched together to form a panoramic picture with 360-degree view. An example shown in Figure 2.4 below.

Figure 2.4 : Single camera with multiple shots

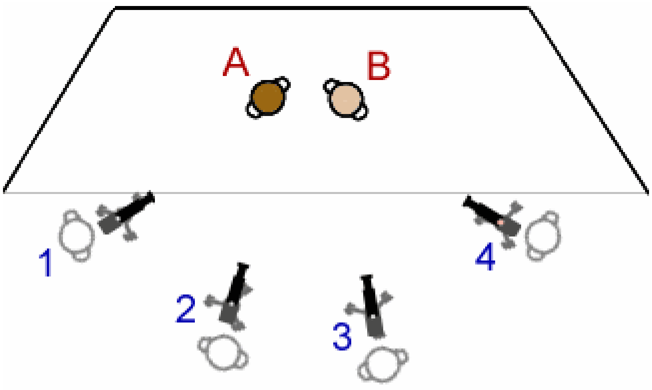

Figure 2.5: Single camera with multiple positions

2.3.2 Multiple camera with single shot

Multiple cameras with single shot which can take a 360-degree of the content that can be stitched together to create full view of content. Its original geometry allows users able to hold rig in multiple directions without creating any blind spot during shooting. An example shown in Figure 2.6 below.

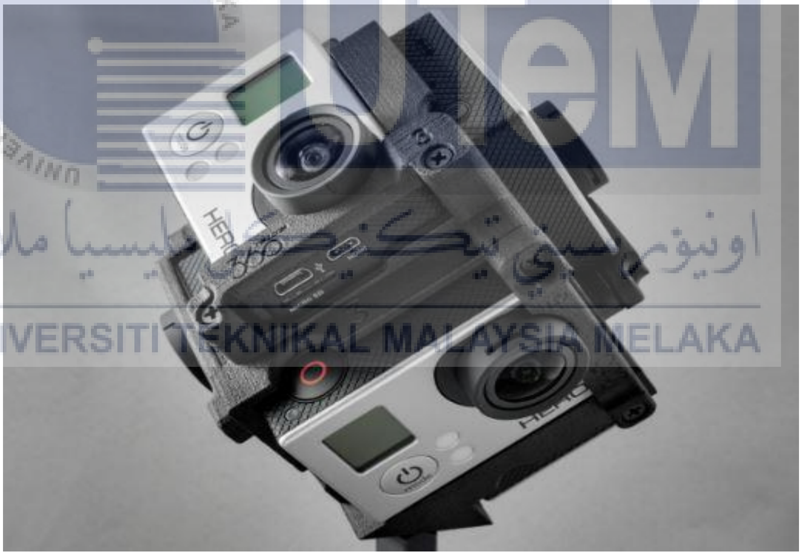

Figure 2.6: Multiple camera with single shot

In general, this project used multiple shots with a camera because the range it covers more than multiple camera with single shot. Hence, this project is to investigate a possible position and orientation of the monitoring rig to create an artificial 360-degree view of chili plants 24 hours by using camera. This project used Raspberry-Pi along Raspberry Pi-Cameras to set up most optimal location and orientation for the camera to enable overlapping of image features and cover the view of all the leaves.

360-degree view of chili plants is a picture having a field of view that covers approximately all side of chili plant.

2.4 Image stitching

Image stitching is a process to combine multiple pictures with overlapping fields to create natural panoramic image composite from a set of images taken with camera[6]. Inlier detection, feature extraction and overlapping region are parts for stitching process. From the previous work that have been done by other researchers. Many evaluation frameworks have been implemented and tested.

The Brown and Lowe Method [7] proposed a method to extract invariant features to draw similar portions in two images because it is resistant to changes of rotation, scale, noise addition and 3D viewpoint. It is called as invariant features. With clutter and occlusion, this algorithm is successful stitched images.

Xiong et. al. [8] presented a method called fast panorama stitching. Fast panorama which is targeted for phones device. By using given images, it can perform optimal seam finding, colour correction through dynamic programming and blending. It required linear memory to ensures a sequential procedure. Integral projections of the differentials along the u, v, x and y axis while u and v axis are major diagonals which created by digest of image. Digests for the two images will shown in Figure 2.7 to 2.9. Luminance compensation and colour for the overlapping area is calculated by colour correction coefficients with the ratios between linearized gamma-corrected RGB values. The local coefficients were used for calculating global adjustment factor of entire panorama. Overlapping region between adjacent images was calculated by error surface. In order to find optimal seam of image stitching, cumulative minimum squared difference is computed for the error surface. By using dynamic programming, optimal seam is identified. This algorithm found out that the next yielded greater results.

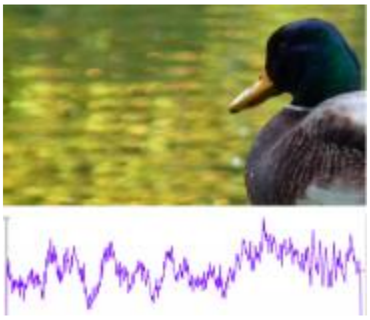

Figure 2.7: Integral Projection for the Left Image

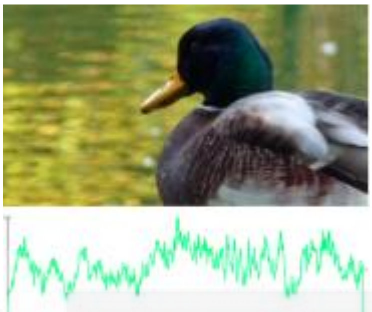

Figure 2.8: Integral Projection for the Right Image

Figure 2.9: Minimum differences overlap for the two integral projections

Zheng et. al. [9] have implemented an efficient video stitching algorithm which aims on removing visual artifacts that produced in the stitching process. As an example, ghosting. This method is critical for reusing computed homography mapping. It will allows computation-intensive part of the process can be pre-computed when the camera are stationary. SIFT method is used as feature, whereas RANSAC method is used to detect inlier.

Yuan et. al. [10] proposed dynamic foreground extraction method that used in stitching video. This method used RANSAC and Harris Corner Detection for stitching the extracted backgrounds.

2.5 Performance evaluation of the output

The method of evaluation in this research was used mean squared error MSE and strutural similarity index metric SSIM to evaluate on the accuracy of stitched images compare with orginal images.

Qureshi et. al. [11] proposed 2 metrics. One is to determine the geometric quality of the stitching. Another is to determine the image's photometric quality. Geometric quality indicates that stitched image has a good seamless flow and geometric alignment. The final result and two unstitched images of the stitching is used in evaluation. SSIM index and A-trous wavelet filter methods were used to evaluate structural similarity. By using this value, image stitching will get a geometric quality index.

Photometric quality represents the seamlessness and colour intensity similarity in stitched image. Authors have proposed two indexes for intensity and colour. SAM index was used in the colour quality assessment index to find the angle between adjacent pixel colour vectors. It used SAM index as an indicator of colour quality of stitching.

IMR value is used as an indicator for intensity quality of stitching to get value for intensity gradient between adjacent pixels. Bovik et al. [12] proposed an universal image quality index which used to compare the quality of two images. 3 factors such as contrast distortion, luminance distortion and loss of correlation used for valuing an image distortion.

Stitching evaluation method is implemented as below. The part of each image is identified which contributes to the seam region or stitched region. For each of the three colour channels over this region, image quality index is calculated. According to human eyes sensitivity towards colours, green colour receives a higher weight than red colour or blue colour. A new quality value is generated with the equation below,

$$Q = 0.299 * R + 0.587 * G + 0.114 * B \ldots \ldots \ldots (1)$$

Wang et. al [13] suggested an evaluation on stitched image in compare with original non-altered version.Comparison by using combined metric of structure, luminance, and contrast. The method is called as SSIM (Structural SIMilarity) index. SSIM index is a product of contrast measurement, luminance measurement and structural similarity component. The measurement of luminance is assumed to be qualitatively consistent with Webers law which states that in human visual system. The changes in luminance is approximately proportional to background luminance in human visual system. Besides that, contrast measurement is consistently with human visual system. It only notices changes in contrast rather than the absolute contrast difference.

Fast stitching algorithm resulted in stitched image with different success. The image alignment component is responsible for the stitched product's accuracy. Therefore, the algorithms results are the best when overlapping between original images is maximal. Algorithm with colour correction component produces accurate results. However, when compared to other stitching algorithms, these results receive a lower preference value from human observers.

Non-linear blending stitcher is the main observation that is expensively CPU-wise. The result from non-linear bleding method is agreeable with Human Visual System especially with the occasional ghosting of dynamic situations. It was discovered that the best stitched images contain strong geometric features indicating that they are more easily matchable with SIFT features. Image stitching depends thoroughly on homography generated using SIFT feature detection. However, non-linear blending has the highest result in evaluation.

As summary, this project will implement MSE and SSIM to evaluate the accuracy between stitched image and original image. MSE is used to measure the error signal between original and stitched images. SSIM is use to extract strutural information from image by finding the similarity between original and stitched images.

CHAPTER 3

METHODOLOGY

3.1 Overview of Project Flow

This project primarily aimed to investigate a possible position and orientation of the monitoring rig to create an artificial 360-degree view of the plant. Image stitching will be analyzed in terms of accuracy of post-produced images in the form of Fourier Transform thresholder image orientation and the coverage area of the plants after stitching.

The previous chapter had briefly discussed the design of 360-degree view monitoring system with images stitching. The parameters that will used for this project was MSE and SSIM. This provides an overview on how this project should be implemented. Therefore, this chapter will discuss on the method that will be utilized to achieve the objectives.

From the start of this poject, the design of the rig was 3 cameras-propose the rig, Raspberry Pi camera was used and placed to take different position such as left, middle, and right side to obtain 3 different position of a chili plant's leaves in order to stitch those images into one. The image stitching algorithm was used in order to stitch 3 images into 1, all stitched images need to resize before compare with original image because inside the coding it needs compare only with same size of image. The process of this research are shown in below;

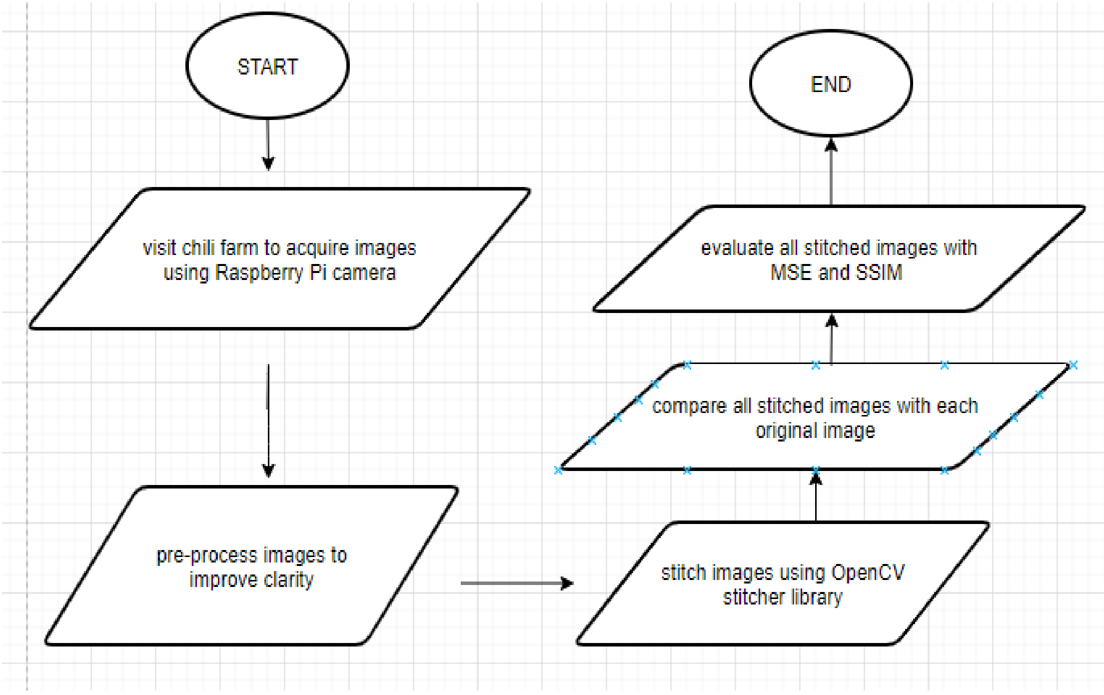

Figure 3.1: Project flow of obtaining data

Figure 3.2 describes on the performance of evaluation that used in this research to stich multiple images into one.

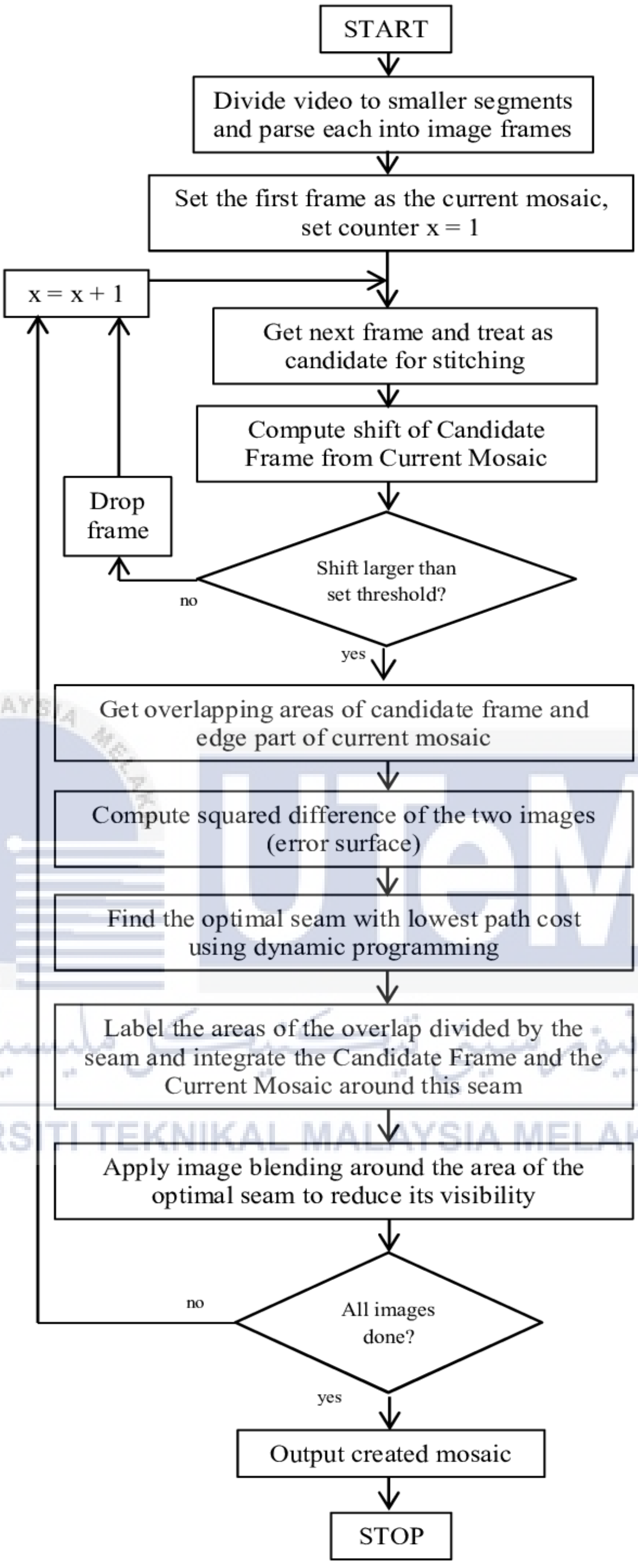

Figure 3.2: Stitching process