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Date : 22/06/2012

DEVELOPMENT OF CITRUS FRUIT SORTING BASED ON IMAGE PROCESSING

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A report submitted in partial fulfillment of requirement for Degree of Bachelor in Electrical Engineering (Mechatronics)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

JUNE 2012

I declare that this report entitle Fruit Sorting Based On Image Processing is the result of my own research except as cited as references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree

Signature : ....

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Date : 22/6/2012

To the almighty ALLAH swt , beloved mother and father, project supervisor and friends.

TABLE OF CONTENT

ACKNOWLEDGEMENT I

ABSTRACT II

ABSTRAK III

LIST OF FIGURE 3

CHAPTER 1 8

INTRODUCTION 8

1.1 Introduction 8

1.2 Problem statement 9

1.3 Objective 9

1.4 Scope 10

CHAPTER 2 11

LITERATURE REVIEW 11

2.1 Introduction 11

CHAPTER 3 18

METHODOLOGY 18

3.1 Introduction 18

3.1.1 Flow chart of process 19

3.1.2 Colour plane conversion 20

3.1.3 Thershold set from benchmarking 20

3.2.1 Area based size classification 22

CHAPTER 4 25

RESULT 25

4.1 Introduction 25

4.1.2 Colour detection result 25

4.1.1 Benchmarking error recognition 27

4.1.2 Benchmarking Error 28

4.2 Area classification result 29

4.2.2 Result of estimate area propotional to the distance of fruits from camera 31

3.5 Error in system performance 33

CHAPTER 5 36
ANALYSIS OF THE RESULT 36
5.1 Introduction 36
5.2 Effect of light ilumination 36
5.3 Analysis of Area Classification 38
5.2 Analysis of Trending Algorithm 41
CHAPTER 6 43
CONCLUSION AND RECOMMENDATION 43
6.1 Introduction 43
6.2 Recommendations 44
References 45

LIST OF FIGURE

Figure 2. 1 : Indirect Natural Sunlight [1] 11
Figure 2. 2 Membership function for ourput quality group and determination of grade for golden delicious apple [2] 12
Figure 2. 3 : Original Image on defected apples.. 14
Figure 2. 4 : Structure of branches in a tree 16

Figure 3. 1 : Flow chart for system flow 19
Figure 3. 2 : Index pixel in an (m,n) image 20
Figure 3. 3 : Partial calculated Hue Matrix Distribution 21
Figure 3. 4 : Calculated hue table 21
Figure 3. 5 : Fruits distance from camera 22
Figure 3. 6 : Area obtained from colour image 23
Figure 3. 7 : Label image using watershed to obtain area 23
Figure 3. 8 : Measurement Of Pixels Area 24
Figure 3. 9 : Fruit Classification (a) Full image (b) half measured (c) 100% measured and (d) more than 100% measure 24
Figure 3. 10 : Benchmarking Error 27

Figure 4. 1 : (a) original image (b) binary after colour recognition (c) labelling region..... 25
Figure 4. 2 : (a) superimposed result of detected fruits (b) region of accepted fruits 26
Figure 4. 3 : Image D (a) Hue distribution , (b) Detected region distribution..................... 28
Figure 4. 4 : Image F (a) Hue distribution , (b) Detected region distribution 28
Figure 4. 5 One example of fruits classification (a) Total region detected, (b) half of visible fruits detected, (c) less than half of single fruits detected and (d) single fruits detected..... 29
Figure 4. 6 : Pixel ranges for 100% detection.. 31
Figure 4. 7 : Pixel ranges for 50% detection.. 32
Figure 4. 8 : Pixel range for less than 50% detection 32
Figure 4. 9 : System Performance Result 34

Figure 5. 1 : Branches missclassify 36
Figure 5. 2 : Missclasification of branches due to saturation of hue colour 37
Figure 5. 3 : Visbile Fruits Detection (100%) 38
Figure 5. 4 : Visible Fruits Detection (50%) 39
Figure 5. 5 : Visible Fruits Detection (< 50%) 40
Figure 5. 6 : System Performance analysis for 100% fruits detection................................ 41
Figure 5. 7 : System performance for 50% detection 41
Figure 5. 8 : System performance for less than 50% fruits detection................................. 42

LIST OF TABLES

Table 3. 1 : Classification of detected area..22

Table 4. 1 : Classification of detected fruits based on pixel area measurement........................30
Table 4. 2 : Classification Data..33

Table 5. 1 : Estimated range for orange pixels 35

LIST OF EQUATIONS

Equation 3. 1 : Matriks benchmarking 20

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ABSTRACT

In implementing harvesting robot one of the critical point is vision of the robot. Thus in this project focus will be in image processing to detect and segment image of fruits from its environment. In detecting and segmenting of possible fruits image, an image is first captured and stored in fundamental of three layers colour system known as RGB colour space. The method applied in this paper will be converting the colour space into HSV plane, generate hue histogram, obtain benchmarking pixel from hue histogram, colour segmentation using benchmarking method, region classification based on pixel area of detected from colour segmentation and range estimation for different images pertaining to their distance from cameras. The result of this project will be on colour detection, area classification and both systems combined. The accuracy of this system achieved 87.5 % of detection for 8 experimental images.

ABSTRAK

Di dalam menjalankan sistem penuaian robot. Sistem penglihatan robot merupakan perkara yang menjadi keutamaan dalam menjejak kehadiran buah di dalam imej.Program yang menggunakan penglihatan sebagai satu proses pengenalpastian adalah perlu didalam menegenalpasti buah dari persekitarannya, Di dalam projek ini pengunaan program pemprosesan imej akan digunakan bagi mengenalpasti kehadiran buah dalam imej dan pengkelasannya dibawah berberapa ketegori.

Pada kebiasaannya imej RGB akan di tangkap dan di simpan sebagai lapisan asas sistem warna sebelum sebarang ubahan dijalankan. Di dalam projek ini penukaran warna bagi RGB kepada HSV akan di jalankan. Penjanaan histogram warna dari satah HSV, pemilihan satu piksel sebagai tanda aras dikira, pengelasan mengunakan tanda aras tersebut, pengelasan kawasan mengunakan hasil dari pengenalpastian warna dari tanda aras dan kajian terhadap jarak yang mempengaruhi hasil keputusan program akan dijalankan.

Keputusan akhir akan dinilai dari kategori pengelasan warna, pengelasan kawasan dan kedua-dua nya sebagai kombinasi. Ketepatan program sebanyak 87.5% dapat di lihat daripada 8 jenis imej eksperimen.

CHAPTER 1

INTRODUCTION

1.1 Introduction

In harvesting process a robot vision is use to detected existance of fruits on tree. Due to this image processing technique is crucial to obtain accurate details of ripe fruits and amount of it before plucking process begin.

Image processing tools will be used in this project to sort and class fruits under several categories. An image is obtain by using selected colour space method of RGB (red, green and blue), YCbCr (luminance and chrominance), HSV (hue, saturation and value) or YIQ (luminance and chrominance for live feed). The acquisition is divided into static image analysis and live feed analysis but in this project the focus will be on static image analysis. A conversion of RGB to HSV color plane is used in this project since in theories HSV colour plane is said to be similar to human preceptions of colours. It is also invariant toward direct and indirect lighting condition making it reliable under different lighting conditions all day long. This colour plane will undergo method of segmentation by calculating it benchmarking range for selected orange colour.

After the result of colour segmentation is obtain in region form an area classification is used as second filtering stages to achieve a more accurate result. By using second stage filtering method after colour detection an error related to unidentified object classifications can be avoid for single fruit detection. Evaluation of system performance would be done by determining percentages of succes in controlled sample of 8 images.

1.2 Problem statement

In detecting fruit image existance of error related to lighting conditions in RGB color plane is detected. Lighting error will cause problem when a shadow become variables that change the input of image color thus create error in color detection. In theories by using HSV color space three colour channel in RGB is summarized into one colour component Hue. Due to this an error can be reduced since one compile colour spaces is invariant towards lighting conditions. As solution for this true colour image of fruits that is obtained in RGB format will first be converted into HSV colour space and benchamarking method for different lighting will be considered.

Other than that a region obtained from colour classification can be misclassified since another out sources with same colour preception can intefere in image analyze thus a need of second filtering is significant to increase accuracy of filtration.

Fruits clustering is also a concern in detecting ripe fruits thus a filtering method of size classification is not sufficient to detect amount of fruits in a cluster, further method of determining the amount of fruits in a cluster will be suggest in this report.

1.3 Objective

1. To obtained orange colour range by manipulating hue index.
2. To evaluate performance and observed result and effect of distance of fruits from camera in area classifications.

1.4 Scope

1.4.1 Fruits (tangerine)

In this paper a citrus known as tangerine in Malaysia with a scientific name of *citrus recticulate* is used as test subject. The ripe tangerine is orange in color and the under ripe fruits is green in color. The fruits were harvest from ripe to overripe. It has a very high demand during celebration and high export need. The captured picture of 8 samples of oranges with same variant of colour and variable distance from camera under different lighting condition will be used as experimented images.

1.4.2 Fruits detection method

An implementation of HSV color analysis technique towards captured image of citrus with leaves and branches in orchard enviroment. Image will be evaluated in Hue histogram of HSV. A benchmarking of hue pixel will be calculated and applied as range to differentiate selected colour with exisctance colour in an image. This method will be used as colour segmentation method. The result in region form of detected colour will then be evaluated per area pixel and classed and several categories of detection less than half fruits, half fruits detection, single fruits detection and a cluster.

CHAPTER 2

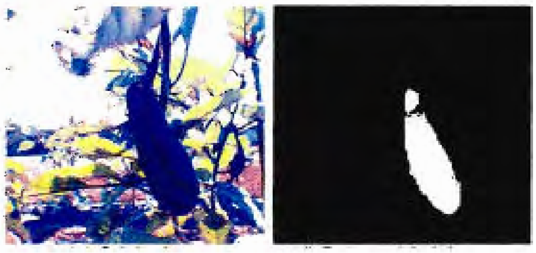
LITERATURE REVIEW

2.1 Introduction

Various method can be applied to determine fruits location and size in an image. A histogram data from a different colour plane contain variant of valuable infromation about the image itself. In determining colour of fruits from it background all colour plan can be manipulated considering objective of detection. In this report two value will be considered colour and shapes area of the fruits detected. HSV colour plan will be manipulated in order to obtained data for image analysis and to test distance of fruits to camera effect theories.

2.1.1 Colour Segmentation

The robotic harvesting system in [1] was designed by Shigehiko Hayashi, Katsunobo Ganno, Yukitsugu Ishii and Itsuo Tanaka. This particular system is designed using color detection and morphological feature of eggplant. The original image is captured and the low gray level pixels were segmented with the use of color characteristic whereby the brightness of fruit was relatively low compared with the other parts. The segmented result achieve will be including some stem and leaves of the eggplant trees.



(a) Original image (b) Detected fruit image

Figure 2. 1 : Indirect Natural Sunlight [1]

As seen in **Figure 2.1** the method applied is suitable under direct or indirect sunlight thus solve the problem of light illumination towards fruit detection. In [1] the method of sorting between ripe and unripe fruits/eggplant were not discussed. In order to strengthen and confirmed the fruits detection a method of fuzzy logic is used as visual feedback control model to increase the percentage of fruit accuracy detection. Colour detection is important since it is the first step in image acquisition of fruits eventhou detection can be done also by considering the size of ripe fruits compared to unripe size the colour detection method is more suitable for most fruits but not highly important for the system in [1] since an eggplant can be pick only when maturity size obtained.

In [2] by Usmail Kavdir and Daniel E.Guyer in 2003 the projects use an artificial intelligence system focusing on detecting ripeness of apples. The application of artificial intelligence chosen is a fuzzy logic membership rule base on crisp value the first rule is if the color is greenish, there is no defect, a well formed large apple and quality is very good. The color is pure yellow (overripe) means there is a lot of defect and badly form formed (small) then the quality is very bad in second rule. A fuzzy logic is applied since a linear parameter as classification is not flexible to obtained accurate level of ripeness detection due to uniform apple color distributions.

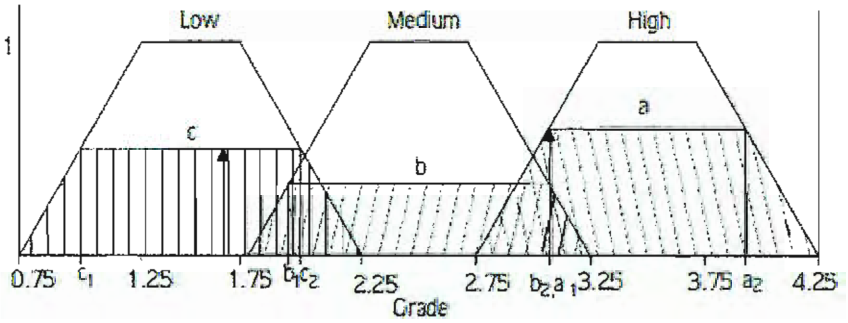


Figure 2. 2 Membership function for ourput quality group and determination of grade for golden delicious apple [2]

Figure 2.2 is an example of golden delicious apple trapezoidal membership function. This function show that the grading system of apple quality is done with non linear classification imitating how human would react towards apple harvesting using vision as sensors of detections. Human contribution in inspecting ripe fruits is considered sas benchmark of designing most of harvesting program nowdays.

In [3] by M. Khojastehnazhand, M. Omid and A. Tabatabaeefar the project is first implement by converting RGB color space into HSI color space under controlled lighting condition. In this project a real color image is compared to captured image using a deviation of RGB value. If the deviation of compared image exceeds certain limit (3sigma) the color is regarded as fruits and if it is less it will be a background. This method can only be implemented under controlled lighting condition since RGB is variants towards light. The advantages of using RGB color plane is that the data from color information triple since it is divided into red,green and blue. In process of sorting RGB color is no longer used for this project. a hue color from HSV color plane is used since it is more stable. The color of hue thresholding will be compared to data of true image color for rule of detection of ripe fruits. The bigger threshold color proportional to the higher grade of apples ripeness.

Another method of grading is design using a RGB modelling and artifical intelligence (fuzzy logic). It is used in [4] by Muhammad Hanif Amaran from UTP Malaysia This method sort three varieties of palm fruit under several classes. They were underripe,ripe and overripe. This classes dependes on color intensity of the fruits. By using CCD camera an image is captured and a program is generate for color segmentation and mean color intensity for color calculation. The decision making is done using fuzzy logic. The train data is inserted to classify oil palm fruits.The program developed has been able to distinguish the three different classes of oil palm fruit automatically with 86.67% of overall efficiency. High effeciency in artificial intelligence method is achieve since it replicate how human decision when determining the fruits ripe however this system is dependable on lighting condition and not suitable with outdoorr enviroment.

Meanwhile in [5] according to Devrim Unay, and Bernard Gosselin a thresholding is sufficient enough for defect detection of fruits. Detection of defect shows error that need to be consider by programmer before acctually applied general detection on outdoor fruits since thresholding is always the interecept data used while evaluating colour of ripe fruits. In [5] by using (Otsu,isodata and entropy) defect can be detected using threshold segmentations. While skin defect such as bruise, russet,rot,scald,scar tissues, limb rub and hail damage is detected using this system the leaves,stem and other obvious missclassification of fruits can also be detected by system.

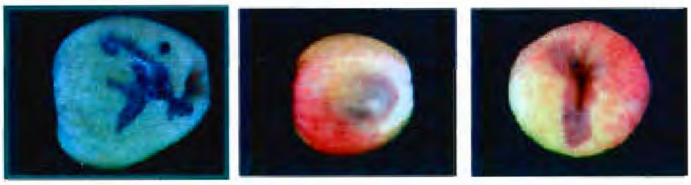


Figure 2. 3 : Original Image on defected apples

In **Figure 2.3** it can be seen that by using a thresholding a stem, calyx region a low intensity region is also classfied as defect making this method limited and only able to operate under certain constarain. Other than that on far edges of fruit illumination artifact have becoming a problem for segmentation due to this a rectangular structuring is done proportional to fruit size. On visual result it also indicates that segmentation accuracy is better in Red and IR filter. This paper method of isodata thresholding have proves that it has 89.2% efficiency in detection.

2.1.2 Area segmentation

Jidong Lv, De-an Zhao, Wei Ji, Yu Chen, Huiliang Shen in paper of [6] the method use for harvesting robot is VFW method. Since angle of recognition is one sort of huge error in robot harvesting system this method is use to realize the real time acquisition technique. In [6] a combination of regional growth algorithm and color characteristics. Using a centroid a preliminary orientation of apple target was calculated and then evaluate. This triangulated method is used to located the area containing fruits and area with no fruits presecense.

In [6] the method of growth threshold algoithm. It is based on the color growing point that acquired from the main color of apple fruits and the area containing growth color. The method is by taking the absolute value of average differences between growing point color and all image colour as the threshold is set using this algorithm. This choice were made by determining the reliability and time compute of the regional growth algorithm. This method is less acurate base on [6] since the expected good result is not achieve. A vector median filter is need to clear detected region area method to remove the noise interference under complex background. A combination of method basing on regional growth algorithm(area of growth pixel) and color characteristic to segment an images.

Another option related to area is by measuring weight of fruits. In [7] data of the area of each citrus in image captured using a CCD camera attached to a grading machine prototype was transformed to the weight of citrus and used for classifying the citrus conformed to SNI grades. The results was then compared to the ones from manually grading. Determination of threshold values according to the SNI classification based on the citrus weight. In [7] the relationship of the area of the object and the weight of citrus was analyzed and area of the object was found useful to classify the fruits based on the size but not in cluster.

$$Y=5.0173x - 38.188 \qquad \textbf{(2 : 1)}$$

$$R2 =0.982 \qquad \textbf{(2 : 2)}$$

Method in [8] is by applying algorithm that works is by removing the background in RGB color space and then extract the ripen tomato using combination of RGB, HSI, and YIQ spaces and then localizing the ripen tomato using morphological features of image. This is a mask method of 3 colour plane. The confusion matrix shows number of correct and incorrect objects that were recognized by proposed algorithm in detecting area using a mask of 3 color plane.

As conclusion the method of image processing can be varied. An implementation of image processing is based on programmer desire. The need of accuracy and method of detection is crucial in process of robot harvesting. In this paper a HSV color plane is choosen both for detection and area classification. Area classification data obtained will be implement in sorting stage to class the fruits into various size. The limitation of this project is in counting amount of fruits in a cluster detected and a suggested method of circular fitting will be in recommendation to improve functionality of program.

2.1.2 Theory of Image Processing

2.1.2.1 Colour saturation

Pixels are connected if their edges or corners touch for 8 connectivity in an image. This means that if two adjoining pixels are on, they are part of the same object, regardless of whether they are connected along the horizontal, vertical, or diagonal direction based on connectivity.Other than 8 connnectivity there is 4 connnectivity function when pixels are connected if their edges touch. This means that a pair of adjoining pixels are part of the same object only if they are both on and are connected along the horizontal or vertical direction. Colour saturation will give error in detection if the selected connectivity is neither 4 or 8.

2.1.2.2 Area affetcted by Distance

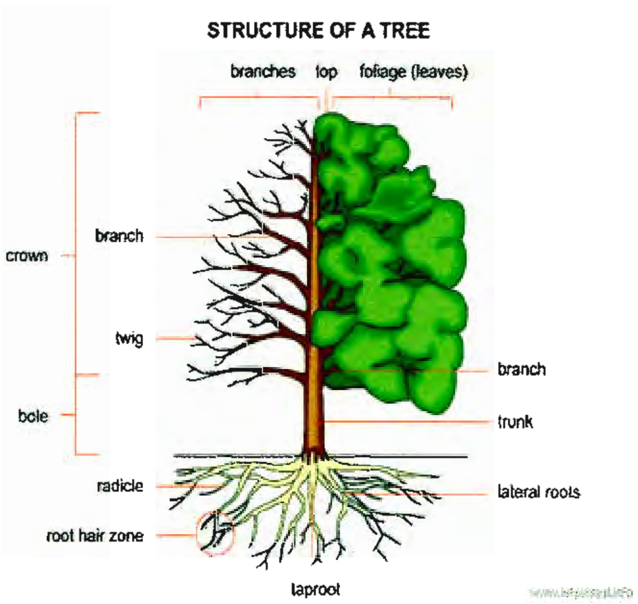

STRUCTURE OF A TREE
branches
top
foliage (leaves)
crown
branch
twig
bole
radicle
root hair zone
branch
trunk
lateral roots
taproot

Figure 2. 4 : Structure of branches in a tree

Based on **Figure 2.4** theories stated that the distance of fruits from its location to vision system will give effect during area segmentation. The measured area of fruit in practical manner will be effected by tree branches distance from trunk since fruits often grow on the tip of those branches. To generalize detection in measuring the distance of detected orange colours with robot vision a range of linear trend data in system performance **Figure 4.8 , Figure 4.9** and **Figure 4.10** in Anlaysis chapter is generate thus proving a constant range of linear trending is sufficient to avoid error of fruits distance from captured vision of robot and solve area classification problem.

2.1.2.3 Morphological Clustering

Morphological reconstruction can be thought of conceptually as repeated dilations of an image, called the marker image, until the contour of the marker image fits under a second image, called the mask image. In morphological reconstruction, the peaks in the marker image "spread out," or dilate. This theories prove that a mask cannot be used to stop it from dilate since there is no edge detection for a fruits that co exist at same location. Due to this a method to calculated number of region with difference in structure and not colour is required.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this project implementation of two methods related to colour detection and area classification will be elaborate.

The first stage in color detection method is the process of determining suitable colour plane. HSV is chosen as the colour plane for this project since it concludes a three colour component of RGB into one component of colour known as hue. A conversion of RGB to HSV is done to obtained hue colour histogram. From the result of generating hue colour histogram a range of orange colour in an image is gained by subtracting the value of index in the selected pixel also know as benchmarking method to all the index component in hue image matrices. This will result a binary image with all orange colour detected as one and background or other than oranges colour as 0.. The result is in region form of fruits component in an images. This region will then pass into size filtering for size classifications.

In stages 2 size classification is used as second filtering method to increase accuracy of the generate region. Pre processing is done in order to restructure region of detected orange component and to clear unwanted noise in this stages. Pixel area classed influence by the distance of capture images from camera visions. A range of accepted pixel area will be classed from experimental images and the range will be undergo estimation process based on manipulating distance variable to achieve accurate range of pixel area accepted. This method is used in order to prove theories on how distance affect region area detected.

3.1.1 Flow chart of process

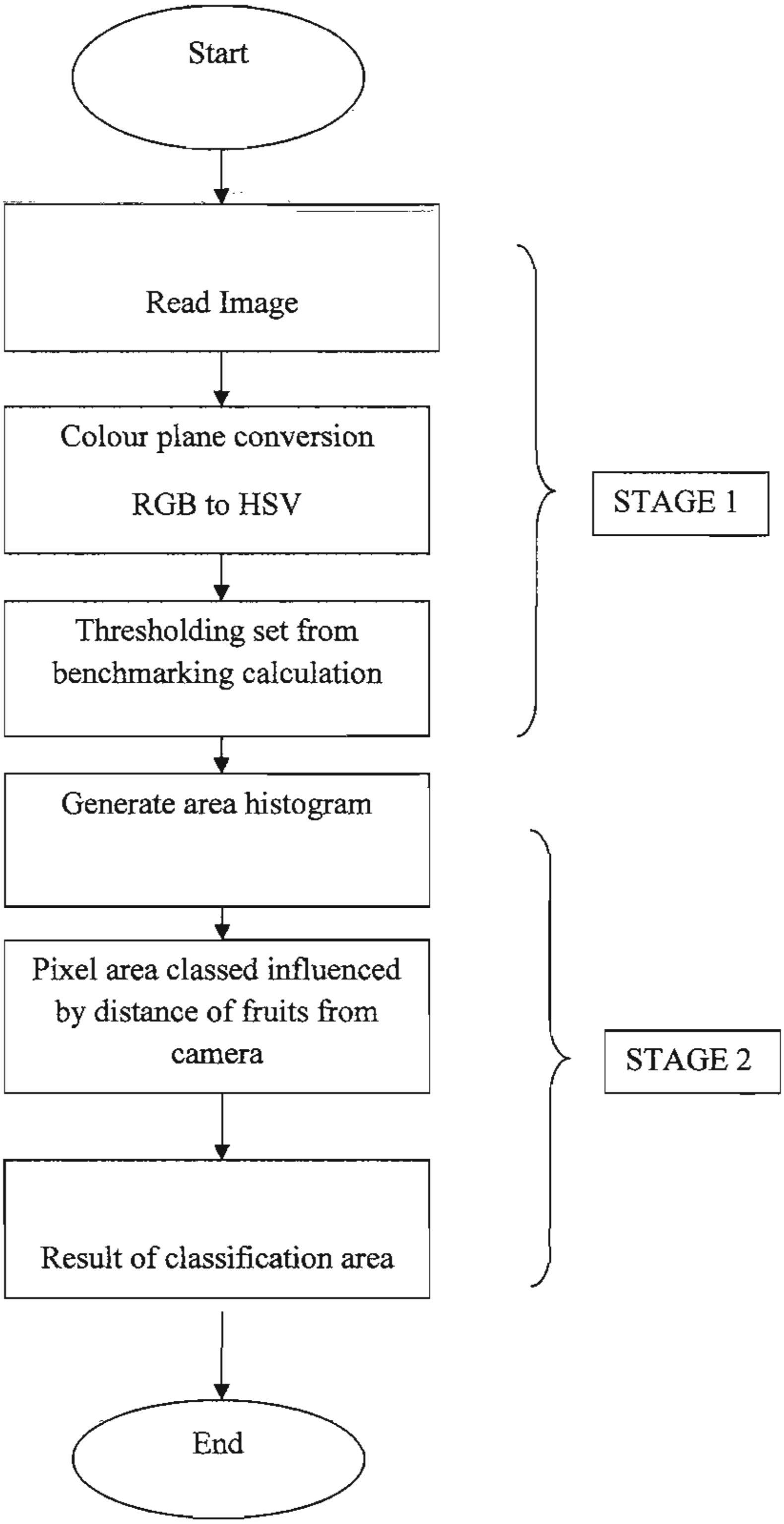

Start
Read Image
Colour plane conversion
RGB to HSV
Thresholding set from benchmarking calculation
Generate area histogram
Pixel area classed influenced by distance of fruits from camera
Result of classification area
End
STAGE 1
STAGE 2

Figure 3. 1 : Flow chart for system flow

3.1.2 Colour plane conversion

The first method is to applied conversion of colour from RGB to HSV. This colour conversion will generate 3 HSV color space of Hue,Saturation and Value. In this project hue colour matrices with dimension of an image as input will be manipulated to achieve benchmarking range for color detection. Saturation and value will not be consider as input data for pixel colour classifications. Calculated matrices of hue range will be inserted as attachment for this report.

3.1.3 Threshold set from benchmarking

Colour analysis on image is done by analyzing hue variation in 8 image sample. A set a of index is choose as benchmarking for colour differentiation. The benchmark is manipulated by substracting each index in hue matrices.In example below a = 0.04478 is choosen as a benchmark and it is used to substract matrices hue (m,n) . Benchmark is choosen based on human preception on hue colour sets.

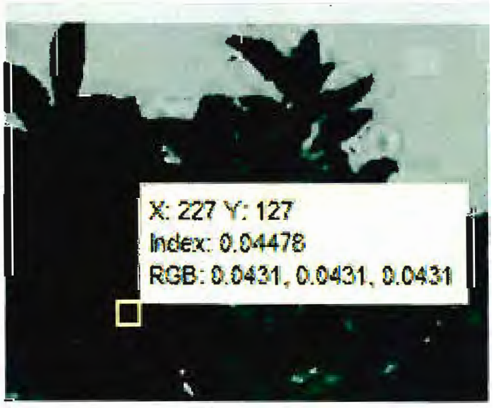


Figure 3. 2 : Index pixel in an (m,n) image

$$a = 0.04478 - \begin{bmatrix} 0.01 & 0.02 \\ 0.03 & 0 \end{bmatrix}$$ .... **Equation 3. 1 : Matriks benchmarking**

$$a = \begin{bmatrix} 0.03478 & 0.02478 \\ 0.01478 & 0.04478 \end{bmatrix}$$