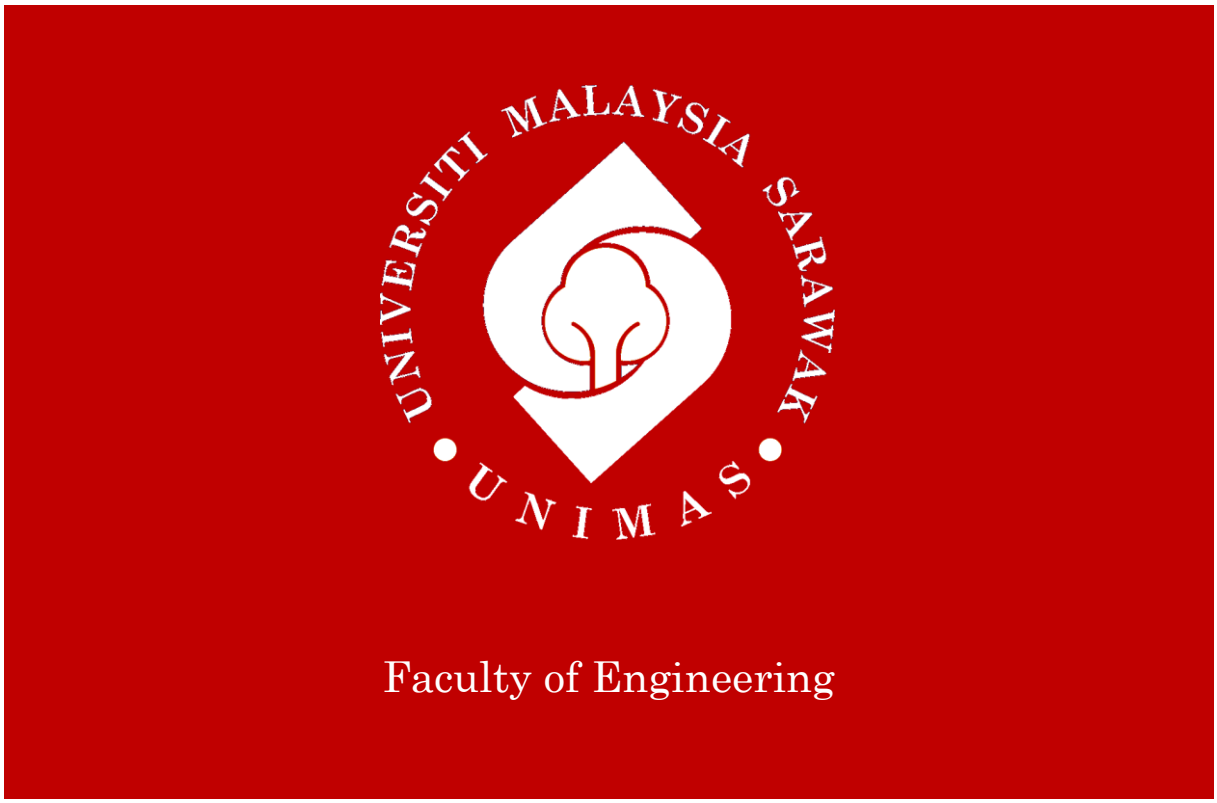


# IMAGE PROCESSING MOBILE APPLICATION FOR BANANA RIPENESS EVALUATION

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**Bachelor of Engineering (Hons) in**

**Electronics Engineering (Computer)**

**2017/2018**

UNIVERSITI MALAYSIA SARAWAK

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# IMAGE PROCESSING MOBILE APPLICATION FOR BANANA RIPENESS EVALUATION

MIRZA SYAZWANA BINTI MOHAMAD NOOR

A dissertation submitted in partial fulfilment of the requirement for the degree of Bachelor of Engineering with Honours in Electronics Engineering (Computer)

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# ABSTRACT

The main objective of this project is to develop an expert system tool for evaluating the ripeness of banana fruit. Mobile application has been identified as the best platform for the expert system tool to reach as many users as possible. By utilizing Google Cloud Platform, the application will send the sample banana image through Google Vision API to get attributes readings from the image sample. The result of the analysis will be compared with application's database of attributes datasets to determine the ripeness of the sample banana. The ripeness of banana is classified to unripe, ripe and overripe systematically based on their key attributes value. This project will also involve the process of collecting samples of banana with different level of ripeness, application development and evaluation to improve the accuracy of the develop applications classification results using image processing and data mining techniques. The significance of this project is being able to aid those who suffered colour blindness and local small farmers. The novelty of this project is the implementation of banana ripeness classification into a multi-platform mobile application.

# ABSTRAK

Objektif utama dalam projek ini adalah untuk membangunkan alat sistem pakar untuk menilai kematangan sampel. Aplikasi telefon pintar telah dikenalpasti sebagai platform terbaik untuk alat sistem pakar memperoleh sebanyak mungkin pengguna. Dengan menggunakan *Google Cloud Platform*, aplikasi ini akan menghantar imej sampel pisang melalui *Google Vision API* untuk mendapatkan bacaan atribut dari sampel imej. Hasil analisis akan dibandingkan dengan pangkalan data atribut aplikasi untuk menentukan kematangan sampel pisang. Kematangan pisang diklasifikasikan kepada tidak matang, matang dan terlebih matang secara sistematik berdasarkan nilai atribut utama mereka. Projek ini juga akan melibatkan proses pengumpulan sampel pisang dengan pelbagai kematangan, pembangunan aplikasi dan penilaian untuk meningkatkan ketepatan keputusan klasifikasi aplikasi yang dibangunkan menggunakan teknik pemprosesan imej dan perlombongan data. Projek ini penting kerana dapat membantu mereka yang mengalami buta warna dan juga untuk petani tempatan secara kecil-kecilan. Inovasi projek ini adalah pelaksanaan pengelasan kematangan pisang ke dalam aplikasi telefon pintar yang menggunakan sistem operasi berlainan.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Study

According to Malaysia's Department of Statistics, banana is the fourth most consumed fruit produce in Malaysia with per capita consumption (PCC) of 9.5 kg per year[1]. Consumption of banana surpasses other fruits such as watermelon, *rambutan* and mango. Banana is consumed daily in Malaysia as the fruit serve as a reliable source of energy.

Local banana fruit is chosen as the species of banana to be evaluated due to its huge availability in the market and has a high demand among the consumers [2]. Imported species of banana found in the large supermarkets are commonly genetically modified organisms (GMOs) which are cultivated to last a longer time than the normal local bananas. The novelty of this project is at evaluating local species of banana using image processing techniques and developed a multi-platform mobile application that could evaluate banana ripeness by utilizing cloud services.

## 1.2 Problem Statement

Bananas are commonly evaluated by its skin colour. However, consumers may want to keep the bananas for consumption at later time (e.g. 2 weeks), thus they would choose to buy immature bananas instead of ripe bananas. Consumers also may have difficulty to know if the banana is at its best-for-consumption period. This project would introduce an accurate solution to determine the maturity of bananas accordingly.

In agricultural industries, there are methods and tools for quality control in large scale production. However, for small scale local farmers, such technology is not easily accessible and available. Beginners or new local banana farmers would benefit from this project, which serves as an expert system tool to help them determine the maturity of produce accurately. (i.e. Experienced farmers may already have the skills required to determine the fruit maturity by observations.)

Furthermore, this mobile application would provide highly available service to users that suffer from colour blindness such as deuteranope. Deuteranope is a form of red and green colour deficit. As they have trouble to determine the ripeness of a fruit primarily through colour distinguishing. Figure 1.1 below show the comparison between the normal vision and colour blind vision of an unripe banana.

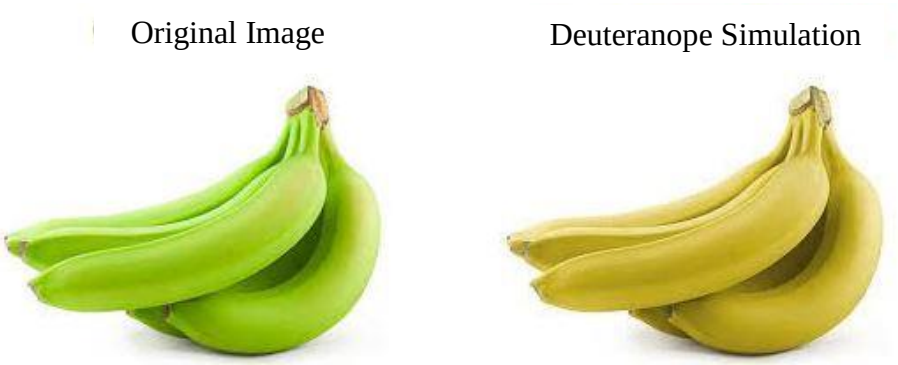


**Figure 1.1: Comparison of Normal Vision and Colour Blind Vision (Deuteranope) of an Unripe Banana**

## 1.3 Objectives

The objectives of this project are:

1. To develop a classification model for image processing of banana ripeness.
2. To integrate classification model into a mobile application platform.
3. To design and build mobile application (as an expert system tool) for evaluation of banana fruit ripeness.
4. To utilize Google Vision API in Google Cloud Platform in processing image attributes from the mobile application.

## 1.4 Scope of Study

This study will be focussing on developing an expert system tool in evaluating the ripeness of banana fruit as recognized locally. Mobile application has been identified as the best platform for the expert system tool to reach the users. Utilizing Google Cloud Platform, the application will send the sample banana image through Google Vision API to get attributes readings from the image sample. The result of the analysis will be compared with application's database of attributes datasets to determine the ripeness of the sample banana.

The ripeness of banana is classified to unripe, ripe and overripe systematically based on their key attributes value. This project will also involve the process of collecting samples of banana with different level of ripeness, building classification model, application development and evaluation to improve the accuracy of the application's classification results based on image processing techniques.

## 1.5 Expected Outcome

The main outcome of this project is a mobile application that is capable of identifying the ripeness of a banana sample. Image classification model will also be designed and developed using image classification techniques. The classification model will be developing in WEKA and the model will later be implemented to a mobile application adaptable for iOS and Android Platform. The mobile application would be able to provide users with real-time evaluation of banana ripeness to assist them in buying and selecting bananas.

## 1.6 Thesis Organization

The first part of the chapter describes the background of study, determined problems, objectives of study, scope of study and expected outcome. The second chapter is reviewing works related to the techniques of image processing and methods of implementations. Published journals are compared and discussed based on the methods, objectives and the outcomes. The third chapter is methodologies of implementing the proposed project. Tools and techniques to be used are described and discussed.

In the fourth chapter, the results obtained from the project are discussed based on the results acquired and the expected results. An evaluation of the results is shown including the explanation of it. In chapter five, the project objective achievements and the current project limitations is discussed with additional features and feature works.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

This chapter will review the existing techniques in image processing from various numbers of published journals. A comprehensive review of journals is important as it provides the researcher a deeper understanding on the field of study and may help to provide comparisons for this research finding. Besides that, reviewing journals may assist the researcher to identify the best possible methods to fulfil the objective of this project. Journals reviewed in this chapter have a similar concept with this study. Methods, objectives and result from the journals reviewed will be compared and discussed.

## 2.2 Image Sampling Technique Review

In collecting sample image, the background colour of image is critical as it will affect the process for background removal of the image in pre-processing phase. As in [3], image was taken with sample illuminators and digital camera inside a wooden box with the internal walls painted in black. Sample image was taken from 1 side of the banana on a matte black cloth as the background shown in Figure 2.1 [3] . Ambient illuminators were taken into account as it is important in reproducible imaging [4].

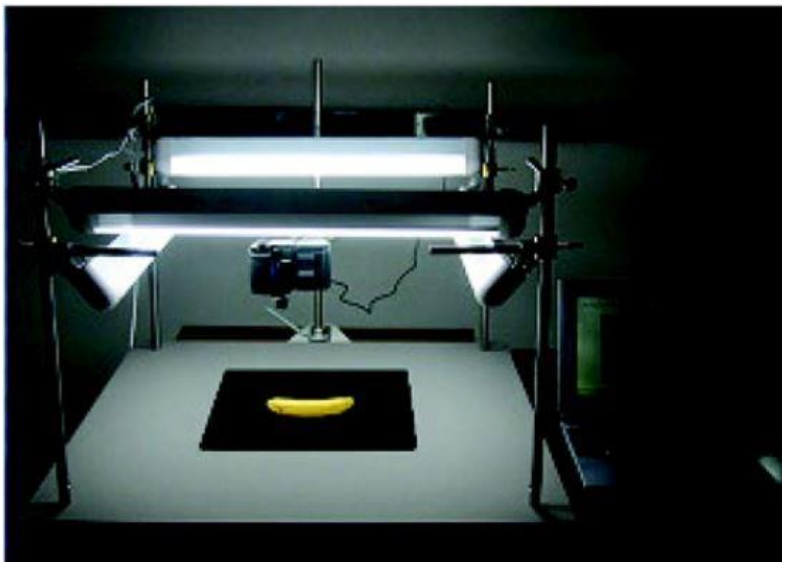

**Figure 2.1: Computer Vision System [3]**

Another existing method for image acquisition is shown as in [5] which the image of the banana were taken on a table. Instead of using black matte cloth as the background, in this method uses non-reflecting white cloth as the background. Samples of fruit were uniformly illuminated similar as in [3] only with minor modifications.

In [3], the resolution used is 2048 × 1536 pixels and it is stored in JPEG format. Resolution for the image of banana is based on the maximum resolution digital camera. As in [5], the resolution used is 3072 × 2304 pixels with format in JPEG format.

## 2.3 Image Processing Technique Review

The first existing method used the image processing toolbox in MATLAB. Functions used are `edge` which used for edge detection, `regionprops` to measure the properties of an image region, `bwboundaries` functions as to trace region boundaries in binary image format and numerous other functions.

These functions applied to determine the size and the ripeness of a banana from its image. Ripeness of banana depends on the types of bananas and the colour changes. Based on the colour parameter for each ripeness stage, colour-based segmentation using L*a*b colour space is used. The main point of this technique is to apply edge detection with the colour changes in order to determine the quality of the banana [6].

Apart from that, in Mendoza & Aguilera [3] image is pre-processed using linear Gaussian low pass filter that will smooth noisy image and thus, improve the quality of the image. Algorithms for pre-processing of images consist of features in colour analysis, brown spot quantification and image texture analysis. In image segmentation process, background of the pre-processed image was removed using threshold value of 50 in grayscale included with edge detection technique based on the Laplacian of Gauss (LoG) operator [3].

Another techniques exist in image processing is by colour and size extraction with RGB colour model. In this method, the background of the image will be removed and the image converted into binary image where 0's in banana region and 1's in background region. Once again, the binary image was converted into its complement image with 1's in the banana region and 0's in the background. This will identify the banana boundaries.

Mask of the banana region will be obtained using polygon vertices[7] which contains 1's in the banana region and 0's in the background as in Figure 2.2 [5]

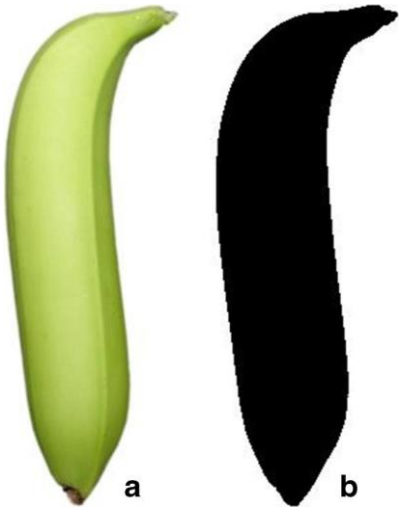


**Figure 2.2: Pre-processed Image (a) Original Image (b) Binary Image of (a) [5]**

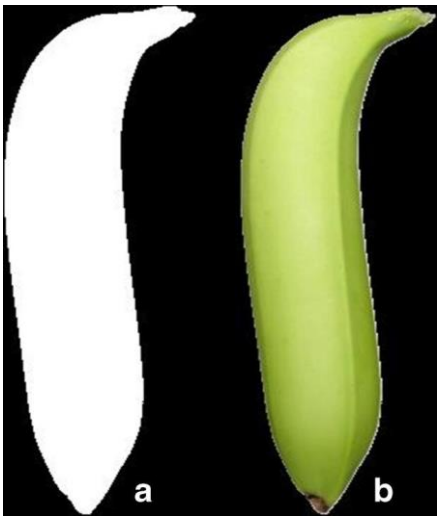


**Figure 2.3: Binary Mask of Pre-processed Image (a) Binary Mask (b) Extracted Banana Region [5]**

Mask will be increased with RGB from the original banana image and each individual colour components were linked together to extract the banana region from the original image as shown in Figure 2.3 [5]. Sample image was in RGB colour model. Hence, the RGB intensity colour distribution of banana was calculated using statistical method obtained from histogram. Histogram for the banana region was computed using the vertices that were stored in the vectors.

Another method recommended by [8] stated that the method presented is simple yet effective colour mapping concept for colour grading. The method is to convert colours in specified range of colours into 3-D RGB colour space into continuous 1-D colour space. The method does not involve any machine learning technique.

As suggested in [9], to detect artificially ripened banana is by converting the original image that is in RGB format into Cyan, Magenta, Yellow and Black (CYMK) format. Reference image is denoted as the standard image and the image will be compared to the banana original image. Deviation from the actual image will be detected as artificially ripened banana.

## 2.4 Methods of Classification

In classification method of banana, there are 7 stages of ripening [3], [10]. Banana ripeness is normally determined by visual inspection according to the pigment changes in the peel of banana by comparing the colour of the peel to standardized colour charts that describe the 7 ripening stages. As shown in Table 2.1 below are the stages of ripening for banana [11], [12].

**Table 2.1: Stages of Banana Based on Colour**

| Stage | Colour |
|---|---|
| 1 | Green |
| 2 | Green with traces of yellow |
| 3 | More green than yellow |
| 4 | More yellow than green |
| 5 | Green tip and yellow |
| 6 | All yellow |
| 7 | Yellow flecked with brown spot |

Based on Prabha & Kumar [5], banana can be classified into 3 categories which are un-mature, mature and over-mature. Ripeness of banana fruit is assessing by the change of peel colour, disappearance of angularity, finger length and diameter. Maturity of the fruit was solely determined based the colour and size values extracted from the sample image. Feature extraction from colour and size was refined to classify the maturity stages. The classification method as suggested is by using colour mean intensity value. Result obtained based on the method applied imply that mean colour intensity algorithm showed 99.1% accuracy in classification of banana ripeness. The area algorithm on the other hand only has 85% accuracy [5].

Figure 2.4 below shows the maturity stages of banana.


**Figure 2.4: Stage Maturity of Banana (a) Under-mature (b) Mature, and (c) Over-mature. [5]**

Apart from using colour mean intensity value as classification method, there are three other types of classifier used in the existing research method which are Support Vector Machine (SVM), Discriminant Analysis and Rule-Based Classification. Support Vector Machine (SVM) is one the method that is useful for classification. The accuracy obtained is 96.5% of radial basis kernel. It is a supervised learning in which data must be trained with a set of training datasets. This classification method can be used to recognized ripeness of banana based on the values of L*,a* and b*[10].

Discriminant analysis is used as classification method. Accuracy of 98% obtained by identifying 49 bananas in 7 stages of ripeness [3]. This classification method is proposed as a simple, fast and accurate. This approach is more consistent, efficient, and economical to identify the ripening stages of bananas than the current instrumental techniques (E.g. hand-held spot colorimeters)

Another classification method that can be used is rule-based classification technique. Rule-based classification contains a set of if-then rules. Several purposes can be used through this classification method such as predictive decision in actual application and in decision support. It is a special type of an expert system.

The main steps in this classification are data acquisition, data pre-processing, learning from data and testing the data. Rule-based system can be constructed into two categories which are based on knowledge based and data based. The rule-based classification is used in this project.

Knowledge based approach is domain dependent. Gaining knowledge and requirements from the expert firstly is crucial as to identify the relations between attributes. Modelling will execute an order to build a set of rules and simulation will check the model accuracy and efficiency. Statistical analysis started to validate if the model is dependable and efficient.

On the other hand, data based approach is similar to machine learning approach which is domain independent. There are two types of machine learning techniques which are supervised learning and unsupervised learning. Supervised learning has the labelled datasets and vice versa for unsupervised learning. With supervised learning, it can predict attributes values by using the labelled datasets. In supervised learning, unknown patterns from datasets can be identified.

A high quality model using this machine learning techniques can be achieved by finding fit algorithms that is compatible with the datasets. Different requirements are needed for different learning tasks [13].

## 2.5 Method of Implementations

The maturity or ripeness evaluation of banana had been implemented as a Graphical User Interface Development Environment (GUIDE) in MATLAB [5]. However, the uniqueness of this proposed project is implementing the developed classification model into a mobile application. Mobile application offers huge practicality for users as mobile devices are already equipped with camera, compared with desktop software that requires additional hardware for image input. Other than that, mobile devices (e.g., smartphone) had already becoming an important aspect of human life with the number of smartphone user is forecasted to grow from 2.32 billion to around 2.87 billion in 2020. Over 36 percent of the world's population is forecasted to use a smartphone by 2018 [14]. Two most popular mobile application platforms are Google's Android and Apple's iOS.