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Identification and Classification of Mango Fruits Using Image Processing

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ABSTRACT

Image processing technology has been widely used in the agricultural field. Most of it applied to the robot that can be utilized for picking fruit and for inspection vehicle. Identification and classification is a major challenge for the computer vision to achieve near human levels of recognition. The fruits and vegetable classification is useful in the supermarkets and can be utilized in computer vision for the automatic sorting of fruits from a set, consisting of different kind of fruits. The objective of this work is to develop an automated tool, which can be capable of identifying and classifying mango fruits based on shape, size and color features by digital image analysis. Initially, pre-processing techniques will be adopted to obtain the binary image using the texture analysis and morphological operations on digital images of different mango fruits. Later, the processed images will be further classified by suitable classification method. MATLAB have been used as the programming tool for identification and classification of fruits using Image Processing toolbox. Proposed method can be used to detect the visible defects, stems, size and shape of mangos, and to classify the mango in high speed and precision.

Keywords: Image Processing, Mango Classification, Mango Identification, Fruit Grading, Defect Detection.

I. INTRODUCTION

In recent years, many researches have been done on fruit quality detection by using computer vision technology, and a lot of significant results have been obtained. There are many research reports, but so far they are in the experimental stage, and the analysis method is far from practical application. Particularly in the defect detection, the current approach used to deal with very slow, cannot be used in actual online work. In some literature, different methods of recognition of defects are implemented, but the need to use both near infrared and mid-infrared camera equipment, the cost of these two devices, making the application of this method is limited, cannot be widely used in agricultural grading equipment. Therefore, it is of importance to study the classification detection method suitable for production. A generalized block diagram of identification and classification of mango fruits is shown in Fig 1.

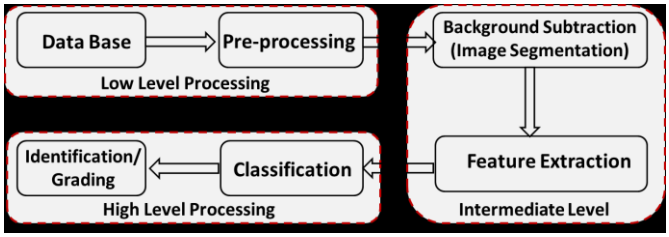


Figure 1. Generalized block diagram of identification and classification of mango fruits.

Mango is one of the world's favorite tropical fruits with an increasing production trend every year. In general, the color of the fruit indicates its maturity and the presence of defects. Its physical appearance affects its value in the market, so it is important to observe proper handling of fruits after harvesting. Sorters must know the requirements that should be followed so that the fruits can be accepted for export.

Sorting objects is usually done using its physical features. Automatic sorting has been studied and developed for different products. The process of classifying mangoes relies on its physical characteristics. This process is presently done using manual labor and is substantially dependent on the

human visual system. Uniformity in the classification process is critical so that its output is guaranteed to satisfy the requirements for exporting mangoes. Fruit categorizations in agriculture have changed from traditional grading by humans to automatic classification over the past 20 years. Many companies are moving to automated classification in many crops such as grading on peaches and oranges [1]. To classify mangoes, we need to be aware of the mango-grading standard. Colour and the size are the most important criteria that are used to sort fruits. However, for sorting of mangoes, there is another major factor which is the skin texture of mangoes that can improve the accuracy of the classification system. The purpose of the study was to implement an image-processing algorithm that can help in automating the process of mango classification. The specific objectives were to apply an image analysis algorithm that can measure the size and shape of a mango and at the same time determine its defective areas and classify the mango using the extracted features.

Demand from the consumer for quality produces, the consistent behavior of machines in compare with humans, the insufficiency of labor and attempt to reduce labor costs are the primary motivations of identification and classification of mango system. The main objective of this work is to design an algorithm that can identify and classify mango fruits based on shape and size features by digital image analysis. In more detail, the research objectives are stated as follows. To develop an algorithm for image processing to identify and classify mango fruits, and test and verify the analysis of image processing with experimental results.

This proposed work is an attempt to implement an extensively designed project based on the topics covered. The project involves a proposed problems and solutions with MATLAB programming. Section I includes a brief description plans, motivation, the necessity of identification and classification of mango and purpose of this project. In Section II, some related works are discussed. In Section III, the problems are discussed which arise during mango image analysis. Section IV explains the whole methodology involved in the completion of the proposed work. In Section V, experimental results of proposed work are discussed. In Section VI, conclusion and scope of future work are made. References are included in Section VII. The proposed work explains the objective of the project, background information, methodology to be followed and expected results.

II. OTHER IMAGE PROCESSING IMPLEMENTATION WITH FRUITS

The review of literature is accomplished very carefully and keenly towards the proper definition of the problem. Different methodologies are being investigated to propose and implement the present work. The reviewed literature has been classified into primary heads for the sake of the comprehensive analysis study such a classification shall help to study literature as per their context. The image processing and computer vision systems have been widely used for identification, classification, grading and quality evaluation in the agriculture area. Some of the most important implementation of image processing in agricultural products is:

- The image processing method for classification of orange by ripeness is developed. In this work, the proper degree of maturity is determined and based on that orange have been classified by histogram and morphological analysis. It uses standard CODEX benchmark, in that quality level of the commercial types of specified orange [2].
- A fusion approach is implemented to for multiclass fruit and vegetable classification task in distribution center and supermarket. A novel unified approach has been introduced, to combine many features and classifier. This method requires less training of data than another method that combines features individually and fed separately to classification algorithm [3].
- Using just one image feature to secure the class separability might not be sufficient, so it is necessary to extract and combine those features which are useful for the fruit and vegetable recognition problem. The result of the system depends upon the image segmentation method, so efficient image segmentation must be used. In the literature, available classifiers work on two classes only, but in the classification problem author considered more than two categories, so it is a major issue to use a binary classifier in a multiclass scenario [4].
- An image processing based hybrid algorithm has been implemented for automatic identification and classification of fruits. The hybrid method relies

on the techniques of Fourier descriptors (FD), spatial domain analysis (SDA) and artificial neural network (ANN) [5].

- By performing digital image processing, defined as the acquisition and processing of visual information by computer, computer vision systems allow analyzing image data for specific applications to determine how images can be used to extract the required information. Among the most important features for accurate classification and sorting of products, it can be mentioned the shape. In this paper for segmentation, a technique base on Hough Transform is used to detection of object shape [6].
- Machine vision has been introduced in a variety of industrial applications for fruit processing, allowing the automation of tasks performed so far by human operators. Such an important task is the detection of defects present on fruit peel which helps to grade or to classify fruit quality. In this paper, a hybrid algorithm, which is based on split and merges approach, is proposed for an image segmentation that can be used in fruit defect detection [7].
- Variable lighting condition, occlusions and clustering are some of the important issues needed to be addressed for accurate detection and localization of fruit in orchard environment. This paper summarizes various techniques and their advantages and disadvantages in detecting fruit in plant or tree canopies. The paper also summarizes the sensors and systems developed and used by researchers to localize fruit as well as the potential and limitations of those systems [8].
- Image processing is an efficient tool for analysis in various fields and applications in agriculture. Today's very advanced and automated industries used more accurate method for different inspection processes of agriculture object. This task is known as robotics task. In Indian agriculture industry, many kinds of activities are done like quality inspection, sorting, assembly, painting, packaging. Above mentioned activities are done manually. By using Digital Image processing tasks done conveniently and efficiently. Using Digital image processing many kinds of task fulfills like object Shape, size, color detection, texture extraction, firmness of purpose, aroma, maturity, etc. In this paper, various algorithms of shape detection are explained, and conclusions are provided for best algorithm even merits and demerits of each algorithm or method are described [9].
- Seasonal fruits, like mango, are harvested from gardens or farms in batches; the mangoes present in each batch are not uniformly matured, therefore, sorting of mangoes into different groups is necessary for transporting them to different locations. With this background, this paper proposes a machine-vision-based system for classification of mangoes by predicting maturity level and aimed to replace the manual sorting system. The prediction of maturity level has been performed from the video signal collected by the Charge Coupled Device (CCD) camera placed on the top of the conveyor belt carrying mangoes. Extracted image frames from the video signal have been corrected and processed to extract various features, which were found to be more relevant for the prediction of maturity level [1].
- This paper focuses on the automatic detection of the pomegranate fruits in an orchard. The image is segmented based on the color feature using k-means clustering algorithm. The K-Means algorithm produces accurate segmentation results only when applied to images defined by homogeneous regions on texture and color. Segmentation begins by clustering the pixels based on their color and spatial features. The clustered blocks are then merged to a specific number of regions. Thus it provides a solution for image retrieval. Thus this paper proposed the simulation results that have been attained using the algorithm [10].

The literature survey gives a keen insight into the various studies done in the field of identification and classification of mango fruit. The study focused mainly on different methods and applications of Mango fruit identification and classification system. A variety of methods has been suggested by the researchers to improve the performance of the system. This literature survey has provided useful insight into different techniques that can be utilized to plan design and development of the proposed method.

III. PROBLEM IDENTIFICATION

To enhance the quality and quantity of the agriculture product, there is a need to adopt the new technology. Mango classification requires early and cost effective

solutions. Image processing approach is a non-invasive technique which provides consistent, reasonably accurate, less time consuming and cost effective solution for farmers to manage fertilizers and pesticides. Some important factors and issues which are needed to be considered while development of identification and classification method for mango fruit is listed below:

A. Background subtraction

It is necessary to extract mango from the cluttered environment, so subtraction of background is essential for proper identification and classification of mango fruits. Background subtraction also reduces the scene complexities such as shading, light variation, background clutter.

B. Feature Extraction

Shape – Region and boundary are two types of shape description feature. Region-based features include grid-based and moment approaches, whereas finite element models, rectilinear shape, polygonal approximation and Fourier-based shape descriptors are boundary-based shape features.

Colour - Colour Value and Degree of Colour distribution are measured based on R, G, and B color component ratio. Example: Colour may be different for example; Orange ranges from being green to yellow, to patchy and brown.

Size - Size may be large, medium or small. It is measured from the maximum length or area or calculated volume from several images.

C. Classifier

In classification process different feature such as geometric and, non-geometric features need to be classified. So, it is necessary to address the issue of proper selection of classifier.

IV.PROPOSED METHODOLOGY

The Proposed algorithm for identification and classification of mango fruits is shown in Fig. 2. Theoretically, proposed algorithm involves three types of processing:

1. *Low-level processing*: In low-level processing input image/dataset is pre-processed. Pre-processing includes RGB to gray conversion, image binarization, and image filtering.
2. *Intermediate-level processing*: Intermediate level processing involves background subtraction, identification of defected region and filtering.
3. *High-level processing*: Classification of mango fruit has been performed in high-level processing.

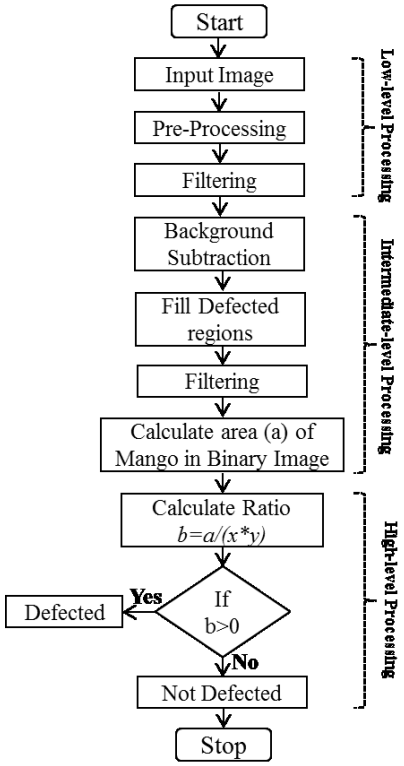


Figure 2*:* Flowchart

Algorithm 1: Identification and Classification of Mango Fruits

Start

Step 1: Read each image into the MATLAB from the particular folder of mango dataset.

Step 2: Convert the original image into greyscale image and binary image.

Step 3: Filter the image using a median filter.

Step 4: Remove or subtract the background from pre-processed image.

Step 5: Filter the image using a median filter.

Step 6: Calculate area of mango image.

Step 7: Calculate quality ratio b=a/(x*y).

Step8: Apply condition

if (b> 0)

Mango is defected.

else

Mango is not defected.

end

Step 9: Finally, we are displaying various results.

Stop.

In general, the implementation of Algorithm for Identification and Classification of Mango Fruits comprises the following five consecutive steps, namely (1) database; (2) pre-processing of the dataset; (3) background subtraction; (4) feature extraction; (5) Identification and classification. The illustration of steps is as follows:

Step-1: Database

Database of 100 calibrated images of mangoes 'Kent' (50 mangos photographed by both sides) is obtained from the web [11]. These samples are mangos cv. 'Kent' in different maturity stages. The image acquisition system was composed of a digital camera (EOS 550D, Canon Inc.) used to acquire high-quality images with a size of 1200 x 800 pixels and a resolution of 0.03 mm/pixel. Images of fruit were stored in JPG format due to internet limitations.

The images were taken by placing each sample inside an inspection chamber in which contained the camera and the lighting system. The vision system used to acquire the images is shown in Fig. 3. The camera was placed at a distance of 20 cm from the samples. Illumination was achieved using four lamps that contained two fluorescent tubes. The angle between the axis of the lens and the sources of illumination was of approximately 45º since the diffuse reflection responsible for the color occurs at 45º from the incident light.

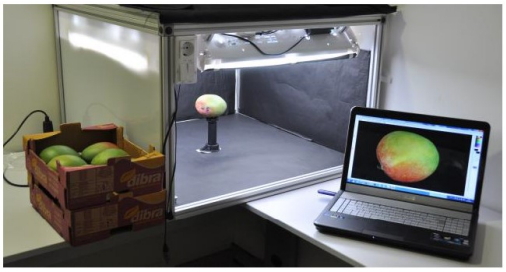


Figure 3: Setup used to capture the images

However, the samples have a curved shape that can still produce bright spots affecting the color measurements. To minimize the impact of these specular reflections cross polarization was used by placing polarizing filters in front of the lamps and the camera lenses. The fluorescent tubes were powered using high-frequency electronic ballast to avoid the flickering effect of the other current and produce a more stable light. Two images of each mango were taken (A and B) from both sides. The settings of the camera used for the acquisition are summarized in Table 1.

Step-2: Pre-processing

Initially, captured mango image is pre-processed. For mango size detection, mainly rely on the mango area as the basis for identification.

Table 1. Camera Settings and Parameters

X Resolution	72 inch
Y Resolution	72 inch
Exposure time [s]	¼
F-Number	22.0
ISO speed ratings	800
Shutter speed [s]	¼
Aperture	F22.6
Flash	No flash
Focal length [mm]	35
Color space	Srgb
Compression setting	Fine
White balance	Cloudy

Step-3: Background Subtraction

The preliminary background subtraction (segmentation) serves two purposes. The first purpose is to remove most of the background pixels for determination of the coarse mango regions. The second purpose is to determine whether mango pixels as a whole are darker than the background. If so, reverse the intensity of the mango image to make all the images have mango pixels that are brighter than the background and therefore improve the performance of the classifiers.

Step-4: Feature Extraction

Finally, use the function *bwarea* can calculate the number of pixels in the white area total. Using the ratio of the total to the pixel value (x*y) of the whole image, multiplying the area of the image, we can get the area of the mango relative to the image, and we can use this area for screening.

Step-5: Identification and Classification

In this step, mango is classified into two classes based on features. In the first class, flawless mangos and in second class defected mangoes are classified. Detection of defected mango has been performed based on surface defect (such as scars, dark spots, etc.). The defected mango is identified by extracting the contour of damaged part. Then damaged part has been filled to find its area in the image as the basis for discrimination.

V. RESULTS AND DISCUSSION

The proposed algorithm is an attempt to make a simple and effective tool for identification and classification of mango fruits using image processing. In this section, the result at various stages of the algorithm is shown and discussed. Experiments were carried out with a set of 28 Mangos. Preliminary results in Figure 5.1 show

that better results are obtainable using proposed algorithm. MATLAB Implementation of proposed algorithm is as follows:

- *Pre-processing*: Initially, raw RGB mango image is converted to grey-scale by grey-scale image processing; MATLAB function rgb2gray have been used for this operation. Original RGB image is shown in Figure 5(a) and converted grey-scale image is shown in Figure 5(b).
- *Background Subtraction:* After pre-processing, grey-scale image is converted to binary image by thresholding by using function *im2bw* with the 0.2 threshold value is shown on Fig. 4(c). so that the mango area is black, the rest of the region is white. Finally, figure reversal is applied, so that black and white colour area reversed when the apple area is white.
- *Feature Extraction:* Finally, use the function *bwarea* can calculate the number of pixels in the white area total. Using the ratio of the total to the pixel value *(x*y)* of the whole image, multiplying the area of the image, we can get the area of the mangorelative to the image, and we can use this area for screening.
- *Classification/ Identification:* Then the grey-scale image is adjusted by using function *imadjust*. Followed by the median filter is used to filter the image using function *medfilt2*. Then, edge detection is performed to create a boundary of contours on filtered mango image by using function edge. Edge detected image is shown in Fig. 4(d). Then, contour (defective part) is filled with white pixel using function *imfill* is shown in Fig. 4(e). Followed by filtering, this is shown in Fig. 4(f). The noise filter for defects in the number of pixels a, the total number of pixels with the picture *(x*y)* then the ratio of b is our basis for judgment, the program set *b = 0*.

The proposed algorithm is tested using 15 mango images. Table 2 listed the results at various stages of an algorithm for 15 mango images. It is observed from the Table 2, proposed algorithm efficiently and accurately determines the quality of mango.

Fig. 5 shows that plot of classification of Mango based on quality ratio b=a/(x*y) value. Among fifteen mango images, seven mangos are defected and eight are not defected. It is also verified from Table 2.

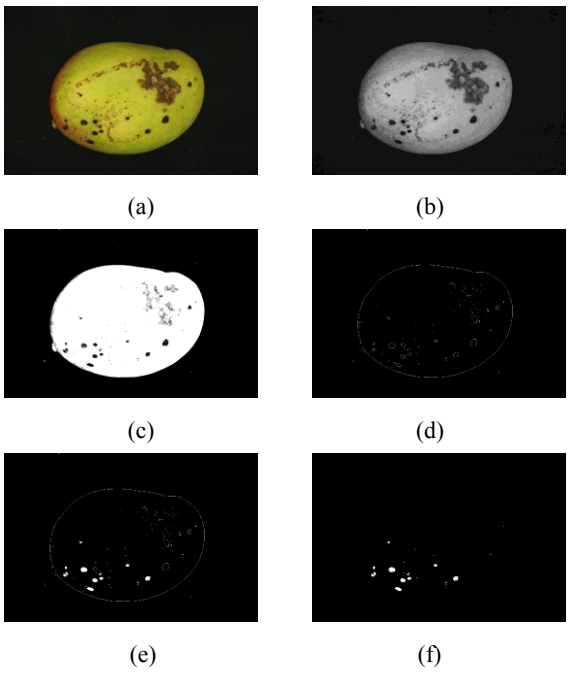


Figure 4: Results. (a) Original Image (b) Grey-scale Image (c) Binary Image (d) Edge Detection (e) Contour Filling (f) Filtered Image.

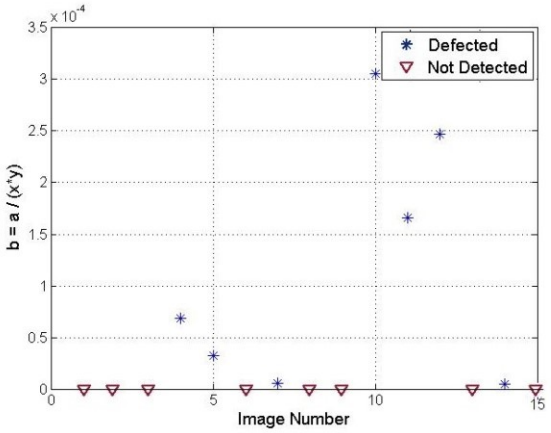


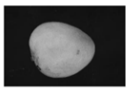
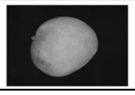
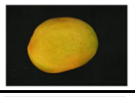
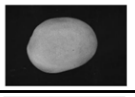
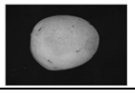
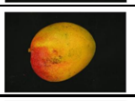
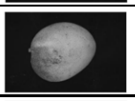
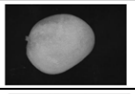
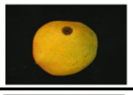
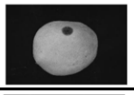
Figure 5: Classification of Mango based on quality ratio b=a/(x*y) Value

VI. CONCLUSION AND FUTURE SCOPE

Due to the growing demand of quality mango fruit, an automatic and reliable identification and classification mechanism to handle the bulk of data are implemented. Algorithms were developed to identify and classify the mango fruit, based on single view fruit images and the mango fruits were categorized into two classes based on the quality ratio. If the value of the quality ratio is greater than the set threshold value, the fruit is rotten. On the contrary, if the value of the quality ratio is less than the set threshold value, the fruit is good. Hence using proposed algorithm, one can able to sort the mango fruits based on quality which is essential for value addition of fruits. In future, we can use color,

perimeter, roundness, and percent defect feature to enhance the accuracy of the algorithm. The roundness and percent defect were used to identify whether the mango's quality was export, local or reject. An optimal and adaptive threshold method can be used for segmentation of mango from the background.

Table 2. Results

S. No	Image Name	Original Image	Grey-scale image	Binary Image	Edge Detection	Contour filling	Filtering	Decision
1	Mango _01_A							No Defect
2	Mango _02_A							No Defect
3	Mango _04_A							No Defect
4	Mango _06_A							Defected
5	Mango _08_A							Defected
6	Mango _11_A							No Defect
7	Mango _12_A							Defected
8	Mango _13_A							No Defect
9	Mango _16_A							No Defect
10	Mango _18_A							Defected
11	Mango _20_A							Defected
12	Mango _21_A							Defected
13	Mango _22_A							No Defect
14	Mango _23_A							Defected
15	Mango _24_A							No Defect

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