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Quality Inspection and Grading Of Mangoes by Computer Vision & Image Analysis

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ABSTRACT
The paper presents the recent development and application of image analysis and computer vision system in quality evaluation of products in the field of agricultural and food. It is very much essential to through light on basic concepts and technologies associated with computer vision system, a tool used in image analysis and automated sorting and grading is highlighted. In agricultural industry the efficiency and the proper grading process is very important to increase the productivity. Currently, the agriculture industry has a better improvement, particularly in terms of grading of fruits, but the process is needed to be upgraded. This is because the grading of the fruit is vital to improve the quality of fruits. Indirectly, high quality fruits can be exported to other countries and generates a good income. Mango is the third most important fruit product next to pineapple and banana in term of value and volume of production. There are demands for this fresh fruit from both local and foreign market. However, mangoes grading by humans in agricultural setting are inefficient, labor intensive and prone to errors. Automated grading system not only speeds up the time of the process but also minimize error. Therefore, there is a need for an efficient mango grading method to be developed. In this study, we proposed and implement methodologies and algorithms that utilize digital image processing, content predicated analysis, and statistical analysis to determine the grade of local mango production.
Computer vision provides one alternative for an automated, non-destructive and cost-effective technique to accomplish these requirements. This inspection approach based on image analysis and processing has found a variety of different applications in the food industry.
Keywords- Agricultural and Food Products, Computer vision, , Fruit ,Grading and Sorting, Image analysis and Processing , Machine Vision, Mango grading, Online inspection, Quality,.

I. INTRODUCTION

Image processing analysis and computer visions have exhibited an impressive growth in the past decade in term of theoretical and applications. They constitute a leading technology in a number of very important areas such as telecommunication, broadcasting medical imaging, multimedia system, and intelligent sensing system, remote sensing, and printing. Analyzing image using computer vision has many potential functions for automated agriculture tasks. Lately, different features of flabbiness, segmentation level, color, size and shape are considered as major functions in the food industry. Flabbiness, color and size are the essential quality of natural image and it performs the significant role in visual perception.

The increased awareness and sophistication of consumers have created the expectation for improved quality in consumer food products. This in turn has increased the need for enhanced quality monitoring. Quality itself is defined as the sum of all those attributes which can lead to the production of products acceptable to the consumer when they are combined. Quality has been the subject of a large number of studies. The basis of quality assessment is often subjective with attributes such as appearance, smell, texture, and flavor, frequently examined by human inspectors.

1.1 FUNDAMENTALS OF COMPUTER VISION

Computer vision is the construction of explicit and meaningful descriptions of physical objects from images. Timmermans states that it encloses the capturing, processing and analysis of two-dimensional images, with others noting that it aims to duplicate the effect of human vision by electronically perceiving and understanding an image. The basic principle of computer vision is described in Fig. 1. Image processing and image analysis are the core of computer vision with numerous algorithms and methods available to achieve the required classification and measurements.

Computer vision systems have been used increasingly in the food and agricultural areas for quality inspection and evaluation purposes as they provide suitably rapid, economic, consistent and objective assessment.

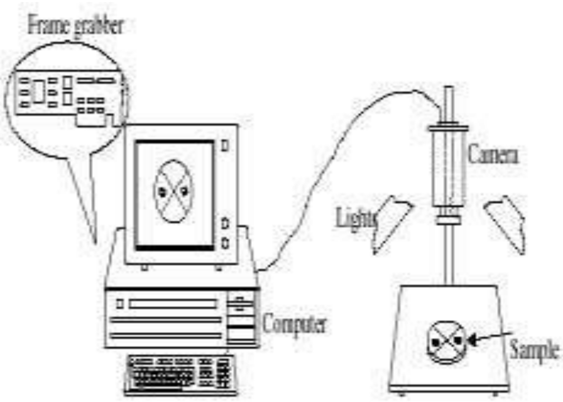

Figure 1: Components of a Computer Vision System

They have proved to be successful for the objective measurement and assessment of several agricultural products. Over the past decade advances in hardware and software for digital image processing have motivated several studies on the development of these systems to evaluate the quality of diverse and processed foods. Computer vision has been recognized as a potential technique for the guidance or control of agricultural and food processes. Therefore, over the past 25 years, extensive studies have been carried out, thus generating many publications.

The majority of these studies focused on the application of computer vision to product quality inspection and grading. Traditionally, quality inspection of agricultural and food products has been performed by human graders. However, in most cases these manual inspections are time-consuming and labor-intensive. Moreover the accuracy of the tests cannot be guaranteed. By contrast it has been found that computer vision inspection of food products was more consistent, efficient and cost effective. Also, with the advantages of superior speed and accuracy, computer vision has attracted a significant amount of research aimed at replacing human inspection. Recent research has highlighted the possible application of vision systems in other areas of agriculture, including the analysis of animal behavior, applications in the implementation of precision farming and machine guidance, forestry and plant feature measurement and growth analysis.

Besides the progress in research, there is increasing evidence of computer vision systems being adopted at commercial level. This is indicated by the sales of ASME (Application Specific Machine Vision) systems into the North American food market, which reached 65 million dollars in 1995. Gunasekaran reported that the food industry is now ranked among the top ten industries using machine vision technology. This paper reviews the latest development of computer vision technology with respect to quality inspection in the agricultural and food fields.

II. IMAGE PROCESSING AND ANALYSIS

Image processing involves a series of image operations that enhance the quality of an image in order to remove defects such as geometric distortion, improper focus, repetitive noise, non-uniform lighting and camera motion. Image analysis is the process of distinguishing the objects (regions of interest) from the background and producing quantitative information, which is used in the subsequent control systems for decision making. Image processing/analysis involves a series of steps, which can be broadly divided into three levels: low level processing, intermediate level processing and high level processing as shown in figure 2.1.

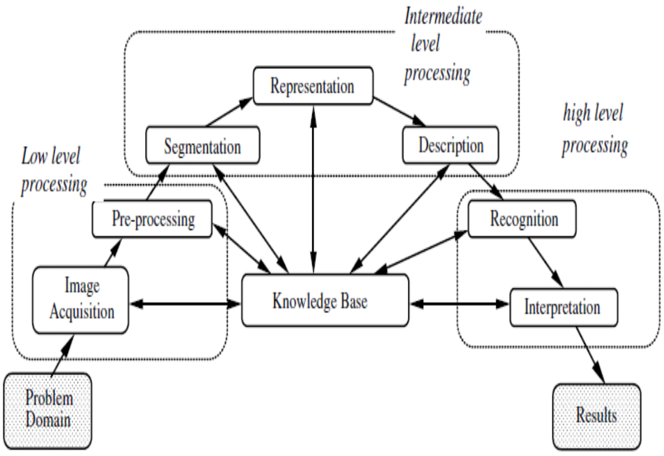

Figure 2.1 Different levels in the image processing process

2.1 INPUT & OUTPUT DETAILS FOR PROPOSED SYSTEM FLOW

This study proposes a mango grading method for mangoes quality classification by using image analysis (as shown in figure 2.2)

1. Input: Image of Testing Mangos
2. Database: Database consist of good quality image of mangos
3. Output: Segmented Image, Plots of the quality ratings for the visual modality and graph of stability of the inspection system

2.2 MODULES

Module 1: Image Read Module

This module is designed to read Capture image and display the image.

Module 2: Image Preprocessing

This module is designed to extract features of mango image.

Module 3: Create Database

This module creates a sample of good mangos.

Module 4: Image Features

This module calculates flabbiness, intensity, level & area of mangos.

Module 5: Comparison

The captured mango image can be compare with database and if match with database it will be selected for further process otherwise it will not selected.

2.3 DETAILS OF EXPERIMENTAL SETUP

1. An experimental setup is necessary to gather data for inspection.
2. In the experimental setup, we are taking a specific product, which is mango.
3. We go for automated non-contact inspection for mango.
4. It is to be observed that, however we are taking a specific food product, the same experimental setup and methodology and be followed for visual inspection of other items where lobs and defects are to be distinguished.

2.4 IMAGE ANALYSIS

1. Thresholding based
2. Region base
3. Edge base
4. Classification base

2.4.1 THRESHOLDING BASED

1. These techniques partition pixels with respect to optimal values (threshold).
2. They can be further categorized by how the thresh old is calculated (simple-adaptive, global-local).
3. Global techniques take a common threshold for the complete image.
4. Adaptive threshold calculate different threshold for each pixel within a neighbor-hood.

2.4.2 REGION BASE

1. Region-based techniques segment images by finding coherent, homogeneous regions subject to a similarity criterion.
2. They are computationally more costly than thresholding-based ones. They can be divided into two groups:

   a. Merging, this is bottom-up method that continuously combines sub-region to form larger ones.

   b. Splitting, this is the top-down version that recursively divides image into smaller regions.

2.4.3 EDGE BASE

These techniques segment images by interpreting gray level discontinuities using an edge detection operator and combining these edges into contours to be used as region borders.

Combination of edges is a very time consuming task, especially if defects have complex textures.

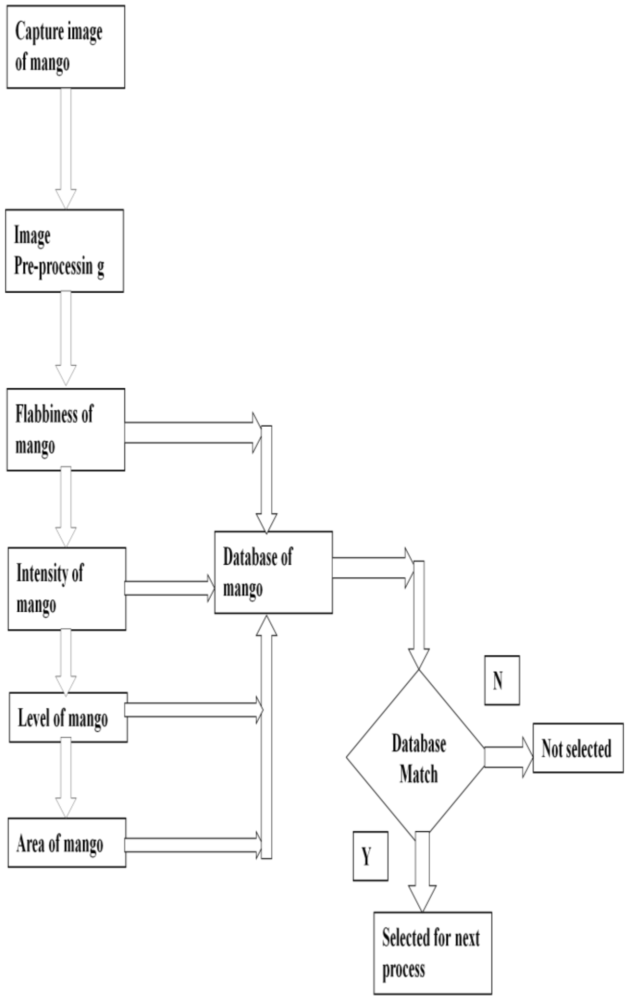

Figure 2.2 System Flow Diagram

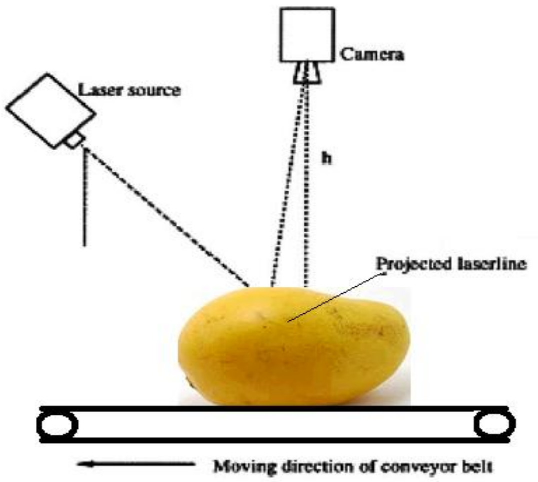

Figure 2.3 Schematic of computer vision system for evaluating the volume of mango on a conveyor belt model

2.4.4 CLASSIFICATION BASE

1. Such techniques attempt to partition pixels into several classes using different classification methods.
2. They can be categorized into two groups, unsupervised and supervised.
3. In unsupervised, desired input output pair for learning is not there, whereas in supervised, it is there.
4. Desired outputs are very difficult and time expensive to determine.

2.5 IMAGE PREPROCESSING

A binarization threshold was estimated from the image intensity histogram. The threshold was used to convert the underlying image into a binary image.

2.5.1 FEATURE DEFINITION AND EXTRACTION

We have defined external quality factors that we refer to as features. These features are flabbiness, size, shape, intensity and defects. We describe below the properties, usefulness and extraction mechanism of these features.

2.5.1.1 FLABBINESS

The flabbiness is used by farmers to determine the date quality. The flabbiest date is considered of the best quality. We have used the color intensity distribution in the image as an estimate of flabbiness. The color intensity distribution is obtained from the gray level image that is obtained from the original RGB colored image using the relationship:
G(x, y) =C(x, y) ÆR +C(x, y) ÆG + C(x,y) Æ B,
Where C(x, y)ÆR, C(x, y)ÆG and C(x, y)ÆB are the red, green and blue components of the pixel x, y in the color image C, and G(x, y) is the transformed gray level.

2.5.1.2 SIZE

The fruit size is another quality attribute used by farmers – the bigger size fruit is considered of better quality. The size is estimated by calculating the area covered by the fruit image. To compute the area, first the fruit image is binarized to separate the fruit image from its background. The number of pixels that cover the fruit image is counted and considered as an estimate of size.

2.5.1.3 SHAPE

The farmers use shape irregularity as a quality measure. Fruits having irregular shapes are considered of better quality. We estimated it from the outer profile of the fruit image.

2.5.1.4 INTENSITY

We have observed that the better quality date yield high intensity images. The intensity is estimated in terms of the number of wrinkles. The number of edges was considered as the number of wrinkles. To determine the intensity the image is binarized and edges are extracted using Sobel operator and labeled.

2.6 CLASSIFICATION

We first visually examined the fruits that we used in this experiment and graded them manually according to their features. The fruits having good shape, large size, high intensity, high flabbiness and no defects were branded as of the best quality, i.e., grade 1. The grade 2 fruits have distorted shape, medium size, low flabbiness, low intensity and no defects and fruits having defects were considered as grade 3 fruits regardless of other features.

III. DISCUSSIONS AND FUTURE WORK

We observed problems in detecting the flabbiness from the color. An impact sensor might improve flabbiness detection. Our fruit quality grading into three grades was based on human perception. A formal feature distribution based method need to be developed to determine the fruit quality grade from the samples. We feel that this should improve the classification accuracy. To determine the feature based grades we are investigating the suitability of the unsupervised learning techniques. We are in the process of applying self organizing map to obtain the fruit grade clusters using the feature distribution in large samples.

IV. CONCLUSION

Computer vision has the potential to become a vital component of automated food processing operations as increased computer capabilities and greater processing speed of algorithms are continually developing to meet the necessary online speeds. The flexibility and non-destructive nature of this technique also help to maintain its attractiveness for application in the food industry. Thus continued development of computer vision techniques such as X-ray, 3-D and color vision will ensue higher implementation and uptake of this technology to meet the ever expanding requirements of the food industry.

An image analysis method has been proposed for mango quality grading. There are two majors part that involved in mango grading. The first part is a digital image processing that prepared four classification factors which implement different methods and the second part was classification system and makes it more like the human classifiers. This study also will replace the human expert mango with this system.

The method has been implemented using the Matlab language and is suitable for various environments that involve uncertainty. The main advantage of this method is the used of inference engine without depending on the human expert. The approximate reasoning of the method allows the decision maker to make the best choice in accordance with human thinking and reasoning processes. This is important to ensure the consistency of the decision.

For further study, we proposed an enhancement on other methods such as Neural Network. K Nearest Neighbor in classification of image analysis to improve grading accuracy result.

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