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MACHINE LEARNING (ML) 2.0 BASED FRUIT INSPECTION SYSTEM

Mr. Kiran H. Wagh
Head of Department of Electronics & Telecommunication Engg.
(VVP Polytechnic, Solapur, Maharashtra, India)

Mr. Sachin Gidde,
Mr. Sumit Gunge,
Mr. Aditya Magar,
Mr. Shrinivas Dasari
Students of Department of Electronics & Telecommunication Engg.
(VVP Polytechnic, Solapur, Maharashtra, India)

Abstract:
With increased expectations for fruit products of high quality and safety standards, the need for accurate, fast and objective quality determination of these characteristics in fruit products continues to grow. 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 fruit industry. Automated inspection of apple quality involves computer recognition of good apples and blemished apples based on geometric or statistical features derived from apple images. This project presents the recent developments of image processing and machine vision system in an automated fruit quality measurement system. In agricultural sector the efficiency and the accurate grading process is very essential to increase the productivity of produce. Everyday high quality fruits are exported to other countries and generate a good income. That is why the grading process of the fruit is important to improve the quality of fruits. However, fruit grading by humans in agricultural industry is not sufficient, requires large number of labors and causes human errors. Automatic grading system not only speeds up the process but also gives accurate results. Therefore, there is a need for an efficient fruits grading or classification methods to be developed. Fruit's color, size, weight, component texture, ripeness are important features for accurate classification and sorting of fruits such as oranges, apples, mangoes etc. Objective of this paper is to emphasize on recent work reported on an automatic fruit quality detection system. This project presents the image processing techniques for feature extraction and classification for fruit quality measurement system.

Keyword: Image analysis and Processing, Computer vision, Fruit, Grading and Sorting, Machine learning, Online inspection, Arduino nano, conveyor belt, grading system.

Introduction

Agriculture is the back-bone of Indian economy as over 75% of its population is directly or indirectly engaged in this profession. Beyond the traditional agriculture, new trends in cropping pattern have been recognized for changing the status of rural community. Importance of horticulture may not be ignored as the horticulture sector contributes about 12% of value-added agriculture. The production

of fruits and vegetables at present is 6.0 million tons and 7.0 million tons respectively and will be enhanced to 9.4 million tons and
10.0 million tons. Grading of these minor fruits is considered very important as it can fetch higher price to the grower. Grading also improves packaging, handling and other post-harvest operations. Grading is basically separating the material in different homogenous groups according to its specific characteristics like size, shape, color and on quality basis. It saves time and energy in different processing operations and reduces the handling losses during the transportation. Normally fruits are graded manually in the country. Manual grading is an expensive and time consuming process and even the operation is affected due to non-availability of labors during peak seasons. The development of graders dated back to five decades ago and the first grader designed was simply a crude slat with a hag attached to the end. Products were inspected on the slat and moved by hand into the bag. These were called slat graders, which led to development of mechanical graders. Grading has been changed very little in the last fifty years. However, the grading process has been fully mechanized. A mechanical grader consisted of a chain conveyor belt, with a bag at the end. Smaller produce fell through the chain, making the grading process easier. In Indian grading is still
being done by hand. Labor shortages and a lack of overall consistency in the process resulted in a search for automated solutions. In vegetable grading, the need to be responsive to market demand places a greater emphasis on quality assessment resulting in the greater need for improved and more accurate grading and sorting practices. Size variation in vegetables like potatoes, onions provided a base for grading them in different categories. Every vegetable producing country had made their own standards of different grades keeping in view the market requirements. Grading is done based on the overall quality features of a fruits by considering a number of attributes like shape, size, color etc. Classification is necessary for the quality evaluation of agricultural produce like fruits and vegetables. Fresh market fruits like apples, oranges, bananas are graded into categories based on several factors such as color, shape, size and presence defects or bruises, blemishes on it. Fruit market is getting highly selective, requiring their suppliers to distribute the fruits of high standards of quality and presentation as well. So there is a increasing need to supply quality fruits within a short period

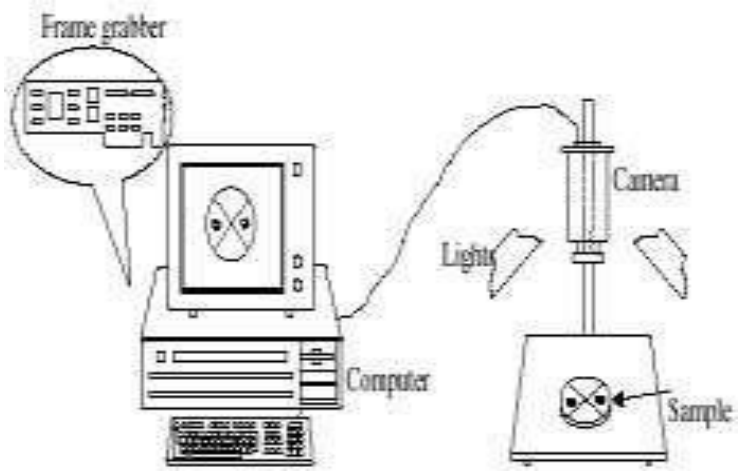

Figure 1: Components of a Computer Vision System

of time has given rise to the development of automated Grading of fruits to improve the quality.
estimated by calculating the area covered by

1.1 Color

Color is also an important quality factor . The color of an object is determined by wavelength of light reflected from its surface. In biological materials the light varies widely as a function of wavelength. These spectral variations provide a unique key to machine vision and image analysis.We have observed that the better quality apple 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.A technique for the spectral image characterization of poultry carcasses for separating timorous, bruised and skin torn carcasses from normal carcasses was investigated by scientist. Carcasses were scanned by an intensified multi- spectral camera with various wavelength filters (542–847 nm) with the results indicating that the optical wavelengths of 542 and 700 nm were the most useful for the desired classification. For separating timorous carcasses from normal ones, the neural network performed with 91% accuracy. Co-occurrence matrix texture features of multi- spectral images were used to identify unwholesome poultry carcasses. The flabbiness is used by farmers to determine the apple 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)ÆB

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. Both quadratic and linear discriminate models had an accuracy of 97% and 95%, respectively. Defects were also detected using the chromatic content of apple images. Possible defect areas were first extracted by means of morphological image reconstruction and then classified according to a predefined list of defects. This system investigated the online inspection of shape and size of apple pieces.

2. Computer Vision System

A computer vision system is a cost effective system and gives consistent performance, a superior speed and accurate sorting and grading of fruits. Computer vision based sorting and grading had undergone substantial growth in the field of agricultural sector in the developed and developing countries because of availability of the infrastructures. Computer vision is the construction of explicit and meaningful descriptions of physical objects from images. 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.

Nowadays, most of the commercial fruit have been graded by the machine-vision technology such as orange, peaches and apples and mango, bananas. The machine-vision technology is the technology that consist a color camera equipped with an image grab device, a bi-cone roller device controlled by a stepping motor, and a lighting source to grade fruit based on the characteristic such as color, size, shape and defection. Computer application is useful in agriculture and food industries in the areas of sorting, grading of fresh products, detection of defects such as cracks, dark spots and bruises on fresh fruits and seeds. The new technologies of image processing and computer vision have been emerged in the development of automated machine in agricultural or food industries. There is increasing

evidence that machine vision or automated grading system is being adopted at commercial level. In automatic fruit grading system, shape, color and size is generally utilized to classify the fruits grade. Color gives necessary information in estimating the maturity and examining the freshness of fruits. Color is one of the most important criteria related to fruit recognition and fruit quality and it is a good indicator for ripeness.

3. Block Diagram

A computer vision system as shown in fig 2 generally consists of basic components: power supply, a camera, computer hardware, keypad, MAX232, LCD display, conveyor belt, DC motors & PIC microcontroller. The system includes the capturing, processing, analyzing & sorting images, facilitating the objective and nondestructive assessment of visual quality characteristics in fruit products. First camera capture the image of apple then captured apple image send to computer for the purpose of analyzing using Matlab. Using Matlab calculate area & size of that captured apple image. The captured apple image can be compare with stored database and if match with database it will be selected for further process and sort the apples grade wise (Grade A or Grade B or Grade C) otherwise it will not selected. A roller conveyor belt is built to hold and move apples in up to one lane. All apple samples are manually placed on the conveyer belt with a random orientation. The apples are rotating and moving when they pass through the field of view of the camera. The surface of each apple can be covered by the camera during the apple rotation. A drive controller, speed controller & dc motors are connected with PIC microcontroller that provides precise timing signals for both on-line

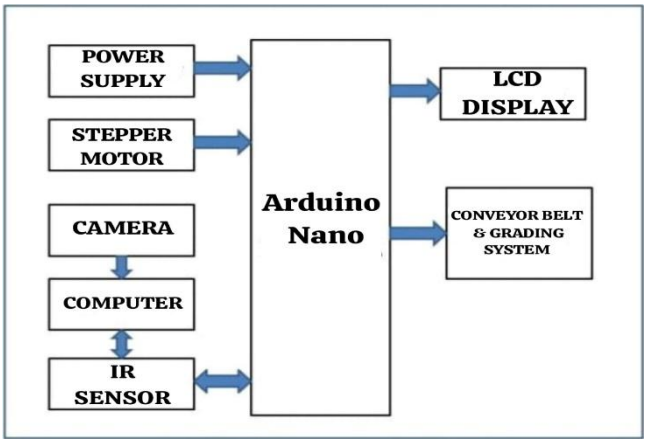

Figure 2: Block diagram of a computer vision system model

mechanical and electrical synchronization for the grading purpose. After rotating apple on conveyor belt & passed through the field of view of the camera then that apple move in mechanical tray using dc motors which are connected with PIC microcontroller for grading purpose. LCD displays the grade of captured apple image.

3.1 Flow System & Result

This system proposes an apple grading method for apples quality classification by using image analysis (as shown in figure 3).

In this grading system input is in the form of image of testing apples. The database consist of good (Grade-A), medium (Grade-B) & bad (Grade-C) qualities of apples & then output is Segmented Image,

plots of the quality ratings for the visual modality and graph of stability of the inspection system.

Step 1: Image Read Module

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

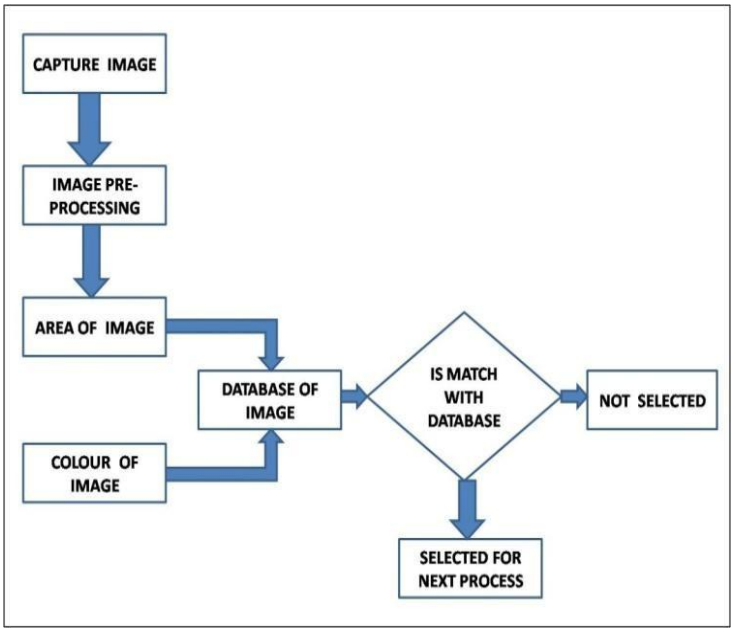

Figure 3: System Flow Diagram

Step 2: Image Preprocessing

This module is designed to extract features of apple image.

Step 3: Create Database

This module creates a sample of good, medium & bad qualities of

Step 4: Image Features

This module calculates area & colour of apples.

Step 5: Comparison

The captured apple image can be compare with database and if match with database it will be selected for further process and sort the apples gradewise otherwise it will not selected.

4. Results

In system image analysis can be applied to make apple grading in Matlab by combine the digital image processing and classification. So its phase will discuss about the result that obtains from this system. Digital image processing in Matlab had been used actually is to extract the parameter or attribute of apple which is size and colour in order to prepare the input for classification. The threshold does not need to be sensitive. In fact, sometimes we face additional edges inside the object and affected the size negatively. So to remove these edges and keep the border. For the colour process, the average from colour components is obtained and based on the number of edges we determined the skin image. Then,

in classification part, the result from the digital image processing is used in the second part, the logic reference. The final grading result based on the logic reference is obtained. The result of apple is shown in table 1.

Sampled Image						
Area or Size	1200000	900000	800000	1100000	600000	700000
Colour Intensity	80	90	91	82	100	95
Grading	Grade A	Grade B	Grade B	Grade A	Grade C	Grade C

5. Conclusion

Normally fruits are graded manually in India. Manual grading is costly, time-consuming and inefficient. Grading of fruits and vegetables is an important operation affecting the quality, handling and storage of produce. Grading systems give us many kinds of information such as size, color, shape, defect, and internal quality. A computer vision & image analysis method has been proposed for apple quality grading. There are two majors part that involved in apple grading. The first part is a digital image processing that prepared grading factors which implement different algorithms and methods and the second part was classification that will also enhances the classification system and makes it move like the human classifiers. This system also will replace the human expert burden by grading apple.

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