Automated Sorting And Grading of Fruits Using Image Processing

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Abstract-*Artificial vision systems and Image processing systems are powerful tools for automatic detection of the fruit quality. In these papers a recent technology that can be used for automatic high speed fruit sorting and grading is proposed. These systems have increased the production of fruits and their commercial value. These systems then explore the difficult areas of research with wider scope in agricultural applications. The systems proposed here basically characterize the shape, size, weight and colour of the particular fruit. Each paper specifies a method for particular fruit. All these methods are implemented and propose a guaranteed percentage of output. Moreover, pros and cons of further studies are highlighted in these papers for student acknowledgment.*

I. INTRODUCTION

Quality inspection of fruits was done manually until 1990. For meeting the greatest challenge today i.e. meeting the food requirements of growing population, technological advancement is finding its way in field of food and agriculture. Human operators are not reliable and efficient hence efforts are being made to replace human operators with automated systems.

These papers define a computer vision technology for installing these systems in the agriculture field. Systems proposed here can not only be used for fruits but also vegetables and food material like chips, popcorns, etc. The reviewed papers give detailed information about various image processing techniques for various fruits. Mass grading and sorting techniques have also been introduced in these papers. The colour, size, shape, weight of a fruit can be obtained from the methods stated in the papers.

The quality fruit can be obtained as desired by making some particular changes in the methods. The methods stated by the studied papers give about 90% of accuracy in the output produced with appropriate implementation and procedural adoption.

II. REVIEW OF LITERATURE

The problem of sorting and grading large number of fruits manually can be solved using recent technology of computer vision and image processing. The typical color image processing based fruit sorting and grading proposed by Guo Feng and Cao Qixin [1] gives a glimpse of how fruits can be sorted on basis of its color. They first segmented fruit area from the original image by using Ohta-color-spaced thresholding algorithm. The next step was to remove noise. In this it was done by using btob algorithm. Then the contour of fruit was determined by spline interpolation based algorithm. The selected classification feature was the color ratio which was calculated using HSI color space. Classic Bayes classifier is used for realizing fruit sorting. These two spaces Ohta and HSI calculations are utilized to get smooth and distinct contour of fruit, so that correct quality feature extraction is guaranteed. Stable and satisfying results were seen from this paper after experimental testing. This system used Crystal Fuji apples and an average sorting accuracy of 90% was achieved.

Based on statistical or geometric features derived from the apple images the computer recognition of good apples or blemished apples is done in automated inspection of apple quality. Another grading technique for apples is discussed by Dr. Sadegaonkar and Mr. Wagh [2]. Here along with size, shape, and weight also the ripeness of fruit is taken into account. They have presented a apple quality grading chart [Table1: result of grading] for understanding. The paper reviews of a simple hardware using PIC microcontroller (PIC 16F877A). It makes use of color camera in order to grab image of fruit, bi-cone roller device which ensures the rotation of fruit in every angle and a light source for better picture quality in order to characterize the fruit on basis color, shape, size and defection. The results obtained are consistent and reliable.

The similar computer vision system can be used for quality inspection of mangoes [3]. The components of this system are similar to that of the system in [2], but the image processing section was specifically designed for mangoes. The flow of image processing is that the input is the image of testing mangoes, database comprises of good quality mango images and the output is the segmented image long with graph

of stability and quality plots. It is basically divided into 5 modules of image reading, preprocessing of the image, creation of the database, getting image features and comparison. The image analysis has four sections; thresholding based, region based, edge based, classification based. In thresholding, pixels are partitioned with optimal threshold value. In the region based homogenous regions are grouped together and are processed. The edge based technique finds edges by detecting the discontinuities in gray level. Edge based technique is time consuming. The classification based is similar to thresholding but here instead of a particular threshold value the partitioning is done using various classification methods. Image processing does the feature extraction, determines the flabbiness, size, shape and intensity. The image processing, analyzing is done using MATLAB language. They have suggested Neural Network, K Nearest Neighbor for image classification.

Identifying the ripeness and quality of fruit is the basic aim of the papers studied here. The apple and oranges were studied for ripeness in Libya [4]. They have implemented certain methodologies based on fuzzy digital image processing. The information gathered using the cameras is processed using MATLAB software. First the RGB component of the apple is determined by MATLAB. The image is further converted into gray scale image to obtain histogram for analyzing the results. The flow chart and frame work of the proposed work (fig.1 and fig.2) help to analyze the systematic implementation of MATLAB software in getting desired results. The step-wise procedure for processing of the apple fruit and orange is described in detailed manner with required graphical image representations. They have concluded that use of hitherto mentioned image processing technique have resulted in better results than manual grading of fruits.

The citrus fruits are trending market. With their sweet and sour taste and various health benefits such as maintaining PH balance they have proved their importance in fruit market and now are the regular intake of growing population. But quality inspection of citrus fruits is kind of difficult as they have slight differences between a rotten and good quality citrus fruits. A well acknowledgement of determining fruit quality in various grades is put forth [5]. They have presented an international standard for indentifying different variety of citrus fruits possible. The paper suggests a vast variety in different sizes, shapes of fruit and their defects with appropriate pictorial representation. This information is useful while deciding the quality of fruit during mass production of fruit outlet when it is to be transported within different nations. This data gives a standard recognition based for transport fruit so that it is accepted worldwide without any grievances.

Another widely spread citrus fruit in market is lemon. This fruit has its medicinal qualities and also has found its way in cosmetic industry as it has anti-tanning qualities. These qualities have made lemon a good to be produced on larger scale and their production is basically increasing the requirement of an accurate methodology for good quality product output. Various stages of sorting and grading lemons are described [6]. For color evaluation they have given two techniques namely RGB color evaluation and HSI color method. RGB method requires more algorithms as there must be an algorithm for each R, G and B. Thus they have used HSI method and have stated mathematical expression for it. After color evaluation another important characteristic is volume evaluation. For volume evaluation they have captured the image of fruit, removed the background and then by dividing the images into distinct sectors, volume of the lemon is obtained. They have proposed calibration stage and sorting stage in brief manner. The results thus obtained were compared with manually calculated values giving accuracy of about 90%. Method described in this here, can also be used for products such as cucumber and eggplant.

Mango, called as king of fruits has a demand with high price in fruit market worldwide. But the mango yield has many problems hence has to be taken good care of during the production process. Our nation exports mangoes on large scale and it is expected to have the best quality. Various methods are proposed for sorting and grading of mangoes. One such method is described [7]. This paper gives detailed examination of each step done during processing of the fruit. For common features of fruits like colour, size, shape and texture some extraction methods like Speeded Up Robust Features(SURF), Histogram of Oriented Gradient(HOG) and Local Binary Pattern(LBP) are discussed. Machine learning algorithms like K-nearest neighbor (KNN), Support Vector Machine (SVM), Artificial Neural Networks (ANN) and Convolutional Neural Networks (CNN) are also discussed. A complete proposed model for fruit classification and grading system and a flow chart for it are provided (fig.3 and 4). The basic stages such as image acquisition, pre-processing, image segmentation, feature extraction using various techniques are being described in brief manner. It provides with a table of summary using the classification and grading (table2).

Mango is largest produced fruit crop in Bangladesh producing about 1047849 metric tons per annum. Geometry based sorting and grading of mango can be done [8]. This technique is used in Bangladesh for mango sorting and grading. For making the process automatic they have used

image acquisition and processing system to extract perimeter, area and roundness features. In this system, images were acquired using a XGA format color camera of 8-bit gray levels using fluorescent lighting. An image processing algorithm based on region based global thresholding color binarization, combined with median filter and morphological analysis was developed to classify mangos into one of three mass grades such as large, medium, and small. Fluorescent lighting was efficient for producing a good quality image for further processing. This system achieved an accuracy of 97% for projected area and Ferret diameter, 79% for perimeter, and 36% for roundness.

As previous paper [8] comprised of geometry based technique another technique proposed Gaussian Mixture Model (GMM) for determining maturity level of the mango [9]. This paper focuses on two factors maturity level of mango and its size. It consists of hardware model for automatic grading and sorting (fig.5). fig.6 describes a chart for defining different levels of maturity observed in mango. It comprises of a video processing technique for fast processing. Still frame extraction from the video is part first step of image pre-processing section, and then followed by filtering of the mango image and edge detection and boundary tracing. The next step is alignment of the mango image followed by all the feature extraction algorithms. The speed of processing here depends on the speed of conveyor belt and gap between the mangoes.

Pesticides are spread on fruits nowadays. These pesticides affect humans. Amount of pesticide on large sized fruit is comparatively smaller than small sized fruits. The fruit for pesticide is a menace is the grape fruit. An efficient way for identifying the treated (having pesticides) and untreated (fresh) grapes is proposed [10]. First the pesticide content of treated and untreated grapes is analyzed using LC-MS/MS and then further imaging based analysis is carried out. Haar filter is used for extracting some discriminating features in frequency domain where image is segmented first from bunch of grapes. Features are selected up to third level of decomposition in wavelet domain and analyzed for discriminatory behavior. The variations in the images are stored and the then related between treated and fresh grapes. This information is used for further analysis for determining whether the grape is treated or untreated. The pesticide content is gained using Support Vector Machine (SVM) classifier. The system was tested and the experimental results indicate that the method is efficient for identification of treated and fresh grapes.

As the smaller fruits are difficult to sort a system for sorting of strawberries is being proposed in paper [11]. The system proposed here works on size, shape and colour of the strawberries. It obtains shape by drawing lines and then by classing those with K-means clustering method for strawberry image. Dominant colour method is used for determining colour of the strawberries and for size recognition the fruit with largest diameter is taken into consideration. This system causes lesser characteristics to grade strawberries into three or four grades hence for solving these multicharacteristic problems, multi-attribute Decision Making Theory is taken. The structure of strawberry automated grading system is shown in fig.1. The system uses single-chip-microcontroller SCM) and a computer for controlling the system. The results show that size detection error is less than 5% followed by colour grading accuracy of 88.8% and shape accuracy of 90%. For one strawberry grading average time required is 3 seconds.

Dates are produced on large scale in Saudi Arabia. It produces nearly 400 varieties of dates. Date being small sized fruit and grown in dessert region comprises of lot more impurities than any other fruit and thus is difficult to sort and grade manually. A system defined in paper [12] proposes an effective sorting and grading technique of dates. In this paper they have defined external quality features such as size, shape and colour. The RGB images of date fruits are captured and system uses them for processing. The system automatically extracts previously mentioned external date qualities from the captured images. The dates are classified into three quality categories i.e. grades1,2 and 3 based on the result obtained by comparing the images. For implementation of this system they have studied the performance of a back propagation neural network classifier. The accuracy is measured by comparing preselected date samples. This systems gives 80% of accuracy in sorting of date fruit.

Most of the systems mentioned above are determined for particular fruit. But there are some systems which can be used for almost all kinds of fruits. One of such system is specified in [13]. It comprises of basic techniques like lighting, image acquisition, color image processing, size, volume, shape estimation and detection of external defects. But apart from this, the paper also signifies the methods for inspection of internal quality of the fruits. It also comprises of real-time automatic inspection systems. It provides with summarized tables for different fruits and vegetables on different basis.

III.TABLES AND FIGURES

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

Table 1:-result of grading

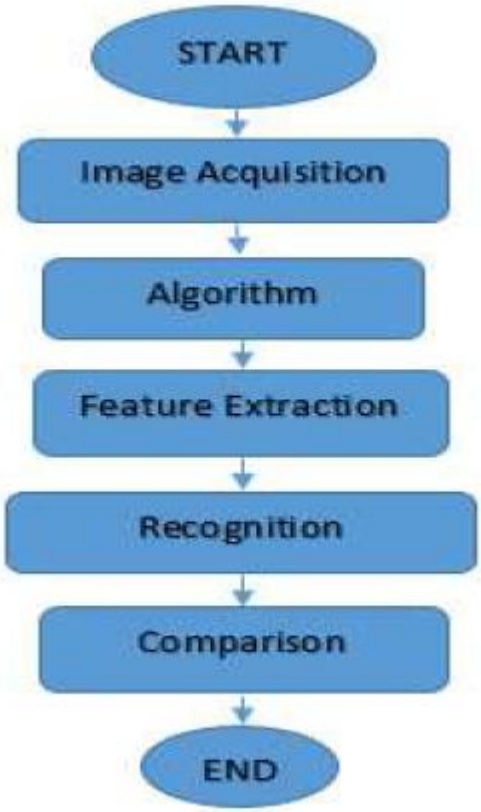

Fig 1:- Flow chart of proposed work

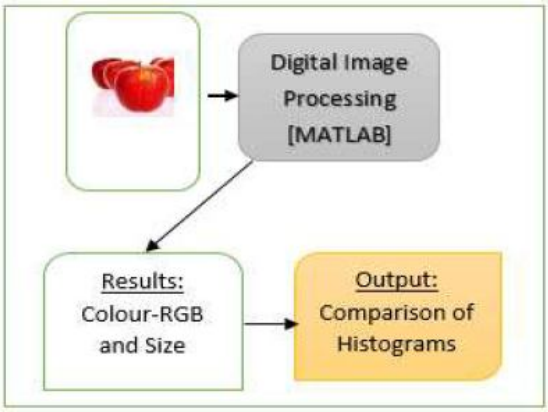

Fig2 :- Frame work of proposed work

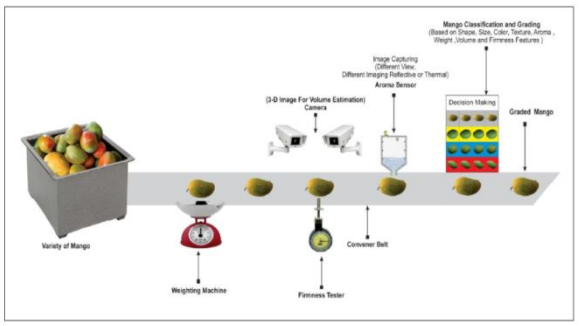

Fig 3:- Proposed model for fruit classification and grading system

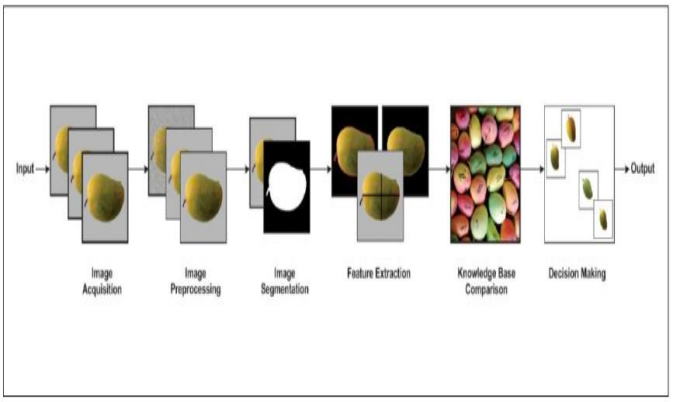

Fig 4:- Flow of fruit classification and grading process

Fruit	Features	Classifier	Accuracy (%)	Reference
Date	Color, Texture	Nearest Neighbor, DA, ANN	83-98	S. Jana et al., 2016
	Size, Shape, Texture	LBP, WLD, FDR	98	G. Muhammad, 2015
	Color	BP		D. Zhang et al.,2014
Mango	Maturity, Size	Fuzzy, Thermal Imaging	90	S. Naik et al., 2017
	Size, Volume	MLR, ANN	96.7	K. Utai et al., 2015
	Shape, Weight	FD, DA/SVM/Weight	98.3/100/95	F.S.A. Sa'ad et al., 2015
	Color, Size	GMM	88.3-90.5	C. S. Nandi et al.,2014
	Color, fractal analysis	LS-SVM	Up to 100	H. Zheng, 2012
Tomato	Color, texture	PCA, SVM	92	N.A. Semary et al.,2015
	Color, Shape, Texture	PNN	84.4	O.O. Arjenaki, 2013
Grapevine buds	SIFT, Bag of Feature	SVM (Detection /Classification)	97.7/86	D. S. Pérez et al., 2017
Orange	Color, Texture	ANN	88	G. Capizzi et al.,2016
Apple	Color, Size	Naive Bayes	91	M. Ronald et al., 2016
Kiwi	Shape	MLR	98.3	L. Fu et al., 2016
Strawberry	Color, Size, Shape	Cluster Analysis, Multidimensional scaling, DA	>68	K. Yamamoto et al., 2015
Mix	Color, shape, texture	PCA, BBO, FNN	89.11	Y. Zhang et al., 2016
	Color(HSV), shape, texture			F. Garcia et al., 2016
	Color, texture	ANN		A. Awate et al., 2016
	Color, Texture	Co-occurrence matrix, RBPNN	97.25	G. Capizzi et al.,2015
	Color, Shape, Texture	PCA, FSCABC, FNN	89.1	Y. Zhang et al., 2014
	Color, Texture	ANN	96.55	M. T. Chowdhury, 2013
	Texture	BPNN	96-98	Fan et al., 2013
	Color, Texture		98	Vishwanath B.C et al., 2012
Review	Color, Size, Shape			S. Khoje, 2015
	Color			Srivastava et al., 2015
	Color, Disease detection, fruit grading			U. Solanki et al.,2015
	Color, Size, Shape, Texture, Surface defect			B. Zhang et al.,2014
	Color, Size, Shape, KNN, SVM, ANN, Fuzzy			R. Pandey, 2014
	Shape			Moreda, G. P., et al., 2012
	Color, Size, Shape, Texture, Volume, Defects and Internal parameter			S. Cubero et al., 2011
	Size			G.P. Moreda et al., 2009

able 2:- Summary of recent fruit classification and grading methods

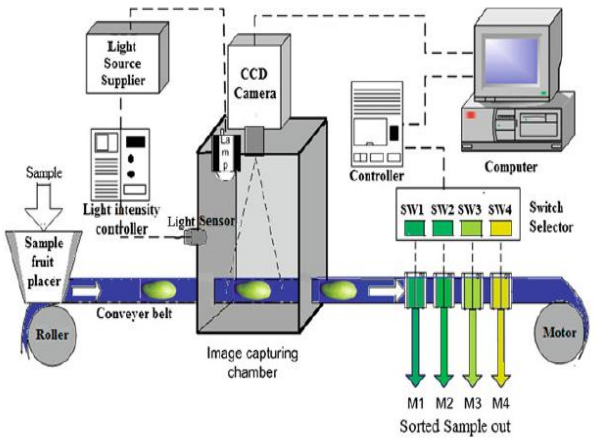

Fig5 :- Proposed model of machine vision based automated mango fruit sorting and grading system

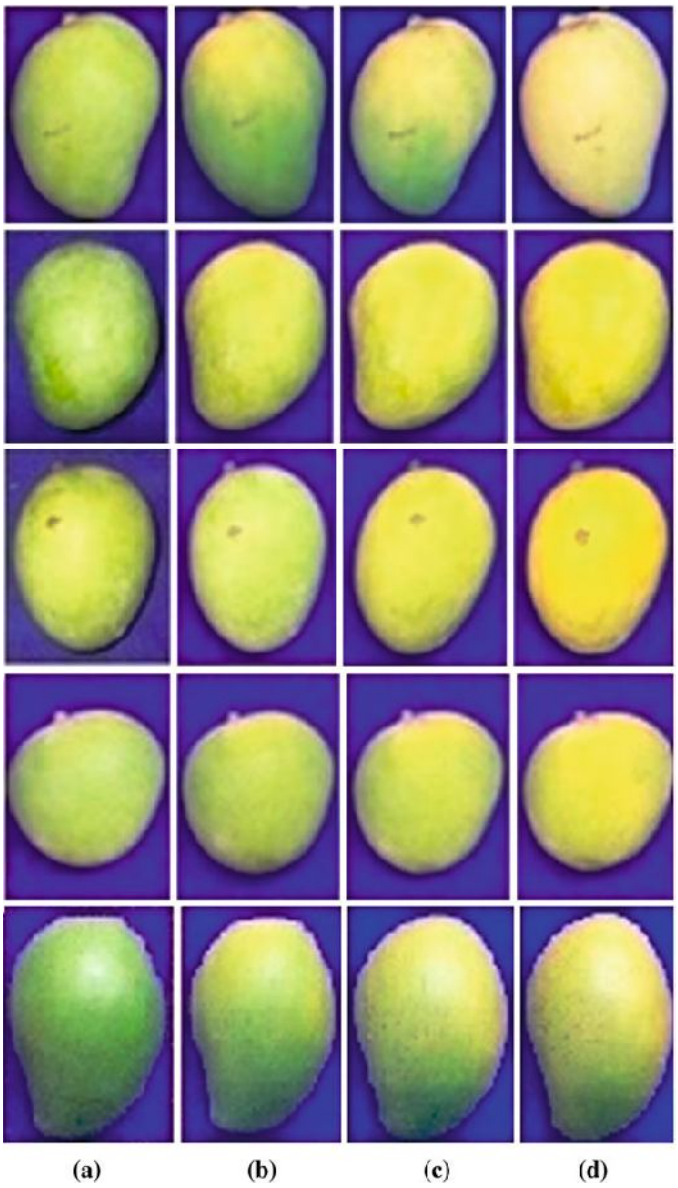

Fig 6:- Images of 5 varieties of mangoes having different maturity level

IV.CONCLUSION

External properties of fruits like color, shape, size and the defects are very important features. These papers have discussed these features and sorted and graded the fruits depending on these properties. All the systems proposed in different papers studied above give 80 to 90% of accuracy and hence can be implemented as per required. The internal defects are also studied in these papers and the output product with maximum efficiency is obtained.

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