A survey of Machine Vision Techniques for Fruit Sorting and Grading

Preet Kamal Singh[1] Vinay Bhardwaj[2]
[1]M. Tech Research Scholar [2]Assistant Professor
[1,2]Department of Computer Science & Engineering
[1,2]Sri Guru Granth Sahib World University, Fatehgarh Sahib, Punjab, India

Abstract— With the growth of technological development, there has been tremendous improvement in the field of inspection for the maintenance of the quality. Now, computer vision technology is extensively used and replacing manual inspection. This paper aimed to study the various types of schemes used for quality grading and sorting of fruits. A few to name them are fuzzy based algorithms and neural network system. Moreover, pros and cons of various schemes used in this field are also discussed here.

Key words: Machine vision technology, Quality grading, Fruit sorting, Neural Network, Fuzzy

I. INTRODUCTION

In today's world of technology, it is necessary to have good quality of fruits for good health of human being and it is possible to rating the fruits according to the dimensions, color or test. But for such rating large human power is needed, so an automatic fruit rating system is required in order to improve the quality detection of fruits. At present, the fruit quality detecting and grading system have the limitation of low performance, high cost, low grading speed and complexity. So, it is required to create a high speed and low cost fruit sorting and grading system.

II. COMPUTER VISION SYSTEM

Computer vision is the procedure of implementing a range of technologies and schemes to provide imaging- based-automatic inspection, procedure management and robot guidance in industrial applications. Generally, computer vision is 'the analysis of pictures to draw out the information for controlling a procedure or activity. Computer vision is a technological innovation for acquiring and extracting an image of a real scene by computer.

CV is used for defect identification and classification. It is also used to know the ripeness of fruits. CV is responsible for the implementation of techniques and approaches which allow the computer system to understand the content of an image. A system of visual inspection requires the collection of images (data) by using sources of radiation such as X-ray, digital camera etc. and then the processing of these images in order to mutate these into knowledge and intelligence required.

Stages (Figure: 1) of automatic inspection system are as follows:

- Image Acquisition- composed of capturing a real image and modifies it into digital image.
- Image Pre-Processing Stage- technique to highlight the item of interest and removal of undesirable information such as grey-level correction, blurring of image, deformation and distortions.
- Image Segmentation- based on similarity of color of every pixel and its neighbouring pixels.
- Extraction of features characteristics – enables the association between area of image and objects in the scene. The characters mostly extracted are diameter, color, perimeter and texture.

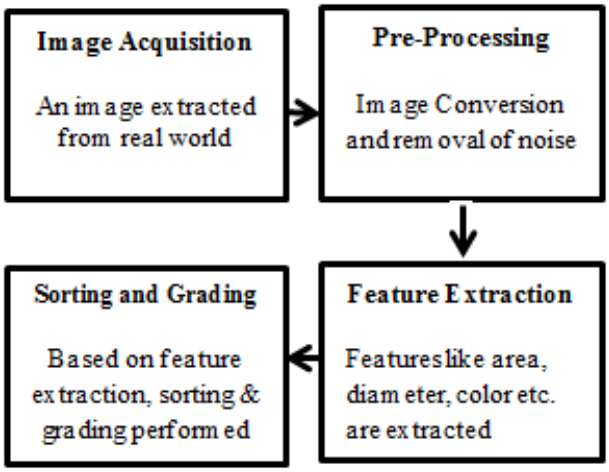

Fig. 1: Sorting and Grading System

III. RELATED WORK

This paper summarizes the overview of various techniques.

A. Fuzzy Logic Technique

Kavdir et al. [3] in paper "Apple grading using fuzzy logic" has used Fuzzy Logic to decide the grade of apples. Different types of equipment were used to measure the quality features like color, size and defects of apple. The set of apples was analysed by both human expert and designed fuzzy logic system. Rating results obtained from

Fuzzy logic system showed:

- 89% accuracy
- Providing good flexibility

Rosli et al. [11] suggested methods and algorithms that use digital fuzzy image processing, statistical analysis to grade the local mango production in Perlis. Design and development algorithm is the main contribution for this study. This approach is implemented through MATLAB.

Advantages:

- 80% accuracy as compared to human expert.
- It uses FIS (Fuzzy Inference System) without depending on the personal.

Dadwal and Banga [2] in "Estimate Ripeness level of fruits using RGB color space and Fuzzy Logic technique" described two techniques- color image segmentation and fuzzy logic system. In this four images of fruits are taken from four different directions and separate the required part from each image. The mean value of primary colors has been calculated and these values are input to Fuzzy Inference System (FIS). FIS editor 1 gives decision about ripeness of that particular part of the fruit. FIS editor 2 gives decision whether the whole fruit is ripe or not. This approach can be operates directly on RGB.

May et al. [11] in "Automated Oil Palm Fruit Grading System using Artificial Intelligence" implemented the technique to check the ripeness of palm fruit. This automated grading system uses RGB model and artificial fuzzy logic. A CCD camera and a computer are used to click images and identify them. This system has 86.67% accuracy as compared to human experts.

Suzanawati et al. [14] in "Classification of Fruits using Probabilistic Neural Features" presented a new method of automated mango and quality grading system using the combination of RGB fibre optic sensor and fuzzy logic approach. This method categorizes the mango into small, medium and large groups (according to size) and compute the highest possible, lowest and mean value based on RGB fibre optics. The automated mango grading system with fuzzy logic has 77.78% accuracy in overall categories.

B. K-Nearest Neighbours Classifier (KNN)

Ninawl et al. [10] in "Completion on Fruit Recognition system using K-Nearest Neighbours Algorithm" described a new fruit recognition technique. This combines four features (shape, size, color, texture) analysis method. In this system, 36 images of fruits have been clicked for identification program. Twenty fruit pictures are used for training session and remaining 16 images are used for testing purposes. The mean value of RGB component, area, perimeter, roundness and entropy are also calculated. This system has 95% overall accuracy.

Woo Chaw et al. [15] in "A new method for Fruit Recognition" proposed a new technique for fruit identification. It analyses, categorize and identify fruit image depending on the shape, dimensions and color of the fruit. KNN is a classification algorithm and used to categorize fruits based on mean RGB shade value, area, perimeter, roundness value of fruit and 90% accuracy is reported in this work.

C. Artificial Neural Network

Monika Jhuria et al. [7] in "Image processing for Smart Farming- Detection of disease and fruit grading" suggested a new technique for detection of disease for mango fruit. This system is used in detecting disease and grading of mango fruit. ANN is used in designing algorithms that detect the disease successfully in mango fruit and categorize the detected disease. This mango system depends on the weight.

Badariah et al. [8] in "Classification of Fruits using Probabilistic Neural Networks - Improvement using Color Features" suggested an intelligent method for fruit sorting and grading using DIP and ANN. For this work, different types of fruits are used like apples, bananas, mangoes and oranges. Color and morphological characters are used to extract features. This classification improved the performance up to 80%.

Sofia et al. [12] in "Color Recognition Algorithm using a Neural Network Model in Determining the Ripeness of a Banana" presented a color identification algorithm using ANN. This method is applied to test the ripeness of banana. The real images of banana are converted into RGB color components. Simple heuristic methods are used rescale the color components. From the rescaled image, histograms are produced and these histogram values are used as feature vector to know the ripeness of banana. They reported 96% accuracy with this method.

Zhang et al. [17] in "Detecting stem and shape of pears using Fourier transformation and an artificial neural network" applies combined Fourier transformation and ANN to know the shape of the pears. The harmonic components of fourier acted as input to ANN. This grading system is also used for the categorization of strawberry.

D. Support Vector Machine

Saresha et al. [13] in "Apples Grading Based On SVM Classifier" suggested effective automatic grading system for apple fruit. The database contains ninety images of apple fruit. This technique categorizes apples as red apple and green apples. In this, RGB images are converted into HSV images and threshold based segmentation method is used to segment apple image from the background. They reported 100% accuracy by using kernel function for SVM classifier.

Zhang et al. [16] in "Classification of Fruits Using Computer Vision and a Multiclass Support Vector Machine" presented a new classification technique. It is based on kSVM method. First of all, images of fruits were captured by using digital camera. The background of images was removed by using split and merge algorithm. Secondly, to compose a feature space the color histogram, texture and shape features of fruit images are extracted then PCA was used to reduce feature space. Finally 3 types of multi-class SVMs are constructed. The experimental outcomes demonstrated that this method achieved 88% accuracy.

Kaur et al. [1] in "Classification and Grading Rice Using Multi-Class SVM" presented machine based algorithm for grading of rice. Indian basmati rice seed are used as sample for grading and classification. To extract the rice kernels from background, maximum variance method is used. Ten geometric features are used to find the percentage of brewer rice, broken rice and head rice. Multiclass SVM categorized the rice by examining the percentage of broken kernel, shape and chalkiness. This system reported 86% accuracy.

E. K-Means Clustering

Gupta et al. [4] in "Infected fruit part detection using K-means clustering segmentation technique" suggested a new problem segmentation of fruits. It is based on color using K-Means clustering algorithm. This algorithm is generally used to find the grouping of pixels presented in an image. This method is very fast and straightforward. In this method, defected apples are used for testing. This method gives precise results and takes less computation time.

F. HSI Technique

Rao et al. [9] in "Color Analysis of fruits using machine vision system for Automatic Sorting and Grading" suggested HIS model for sorting and grading of fruits. He introduced a system for online sorting and grading of apples based on size, color and shape. Images are taken by using a digital camera. Frame grabber card is used to separate frames and convert the image into RGB color model. RGB model is converted into HIS model using converting equations. They achieved 98% accuracy in color inspection.
Abdullah et al. [6] in "Color Vision System for Ripeness Inspection of Oil Palm" applied the HIS model and used multivariate discriminate analysis to categorize oil palms

into grades of quality according to 'Palm Oil Research Institute of Malaysia inspection standards. This reports 9% misclassification.

G. Histogram Method

Jackman et al. [2] in "A fruit Detecting and Grading system using Histogram Method" suggested a computer vision system. This method is used for food quality evaluation based on color, size and shape using digital camera and other low cost equipment. He proposed three techniques- Run length, Pixel Co-occurrence and Difference Histogram Methods for the extraction of texture features. He also proposed Fourier transformation. Drawback of this technique is it should considered only when a surface image can be reproduced by a small number of frequencies. Wavelet analysis is given as alternative. It is the best method for image texture analysis. Another alternative to classical method is fractional dimension. It is a powerful and robust method.

H. RGB Color Method

Khojastehnazhand et al. [5] in "Development of a lemon sorting system based on color and size" provided an efficient technique for sorting of lemon. It is based on the color and size of the lemon. After capturing the images, these are converted into RGB (red, green, blue) color space. Algorithms are implemented to grade lemons in Visual Basic 6.0 programming language.

Fruit	Technique Used	Features	Classification Accuracy (in %)
Apple	Statistical Learning	Area, mean intensity	79.0
	Fuzzy Logic	Area, length, breadth	96.25
	Artificial Neural Network	Surface quality conditions	93.3
Mango	Thresholding	Flabbiness, shape, size	Not specified
	Fuzzy Logic	Area, length, breadth	98.75
Banana	Fuzzy Logic	Area, length, width	81.25
	ANN	Ripeness	96
	Fuzzy Inference System	Ripeness	Very fast
Oil Palm	MLP Classifier	Color, oil content	86.67
Pear	Artificial Neural Network	Shape features	90
Strawberry	Artificial Neural Network	Shape	91

Table 1: Comparative Analysis of food Grading techniques

IV. Conclusion

This paper presented the recent developments in CV for the sorting and grading of fruits based on the features like shape, size, perimeter, area, texture etc. in the field of the agriculture. Fuzzy and Artificial Neural Network based classification methods proved better for the quality determination

References

[1] Harpreet Kaur, Baljit Singh "Classification and Grading Rice Using Multi-Class SVM", International Journal of Scientific and Research Publications, Volume 3, Issue 4, April 2013 1 ISSN 2250-3153.
[2] Gomes, Juliana Freitas Santos, and Fabiana Rodrigues Leta."Applications of computer vision techniques in the agriculture and food industry: a review", European Food Research and Technology 2012: 989-1000.
[3] Ismail Kavdir, Daniel E. Guyer "Apple Grading Using Fuzzy Logic" Turk J Agric For 27 (2003) 375-382.
[4] Jay Prakash Gupta, 'Infected fruit part detection using K-means clustering segmentation technique", International journal of Artificial Intelligence and interactive multimedia, Vol: 2, pp. 67-71.
[5] M. Khojastehnazhand, M. Omid and A. Tabatabaeefar, Development of a lemon sorting system based on color and size, African Journal of Plant Science Vol: 4, No:4, p.p. 122-127, April 2010
[6] Mohd Z. Abdullah et al, 2002, "Color Vision System for Ripeness Inspection of Oil Palm", Elaeis Guineenszs, Journal of Food Processing Preservation 26 213-235, Malaysia.
[7] Monika Jhuria, Ashwani Kumar,Rushikesh Borse, "Image processing for Smart Farming :Detection of disease and Fruit Grading", proceeding of the 2023 IEEE second international conference on image processing (ICIIP-2013).
[8] Nur Badariah Ahmad Mustafa, Kumutha Arumugam, Syed Khaleel Ahmed, Zainul Abidin Md Sharrif, "Classification of Fruits using Probabilistic NeuralNetworks - Improvement using Color Features"
[9] P. Sudhakara Rao, 2009, "Color Analysis of fruits using machine vision system for Automatic Sorting and Grading", J. Instrum. Soc. India 34 (4) 284-291.
[10] Pragati Ninawe1, Mrs. Shikha Pandey, "A Completion on Fruit Recognition System Using K-Nearest Neighbors Algorithm", International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) Volume 3 Issue 7, July 2014
[11] Rosli B. Razak, Mahmod B. Othman, Mohd Nazari bin Abu Bakar, "Mango Grading By Using Fuzzy Image Analysis", International Conference on Agricultural, Environment and Biological Sciences (ICAEBS'2012) May p.p. 26-27, 2012.
[12] Siti Sofiah, "Color Recognition Algorithm using a Neural Network Model in Determining the Ripeness of a Banana" Proceedings of the International Conference on Man-Machine Systems (ICoMMS) 11–13 October 2009, Batu Fer ringhi, Penang, Malaysia.
[13] Suresha M Shilpa N.A Soumya B "Apples Grading Based On Svm Classifier International Journal of Computer Applications" (0975 – 8878) On National

Conference on Advanced Computing and Communications - Ncacc, April 2012.

[14] Suzanawati Abu Hasana, Teoh Yeong Kina, Suraiya Sauddin@Sa'duddina, Nur Badariah Ahmad Mustafa, Kumutha Arumugam, Syed Khaleel Ahmed, Zainul Abidin Md Sharrif " "Classification of Fruits using Probabilistic Neural Networks – Improvement using Color Features".

[15] Woo Chaw Seng,Seyed Hadi Mirisaee" A New Method for Fruits Recognition System".

[16] Yudong Zhang and Lenan Wu, "Classification of Fruits Using Computer Vision and a Multiclass Support Vector Machine", Sensors 2012, Vol: 12, p.p. 12489-12505.

[17] Ying, Y., Jing, H., Tao, Y., & Zhang, N., 2003, "Detecting stem and shape of pears using Fourier transformation and an artificial neural network", Transactions of the ASAE, 46(1), 157–162.

[18] Z. May, M. H. Amaran, "Oil Palm Fruit Grading System using Artificial Intelligence", International Journal of Video & Image Processing and Network Security IJVIPNS-IJENS Vol: 11 No: 03, 2011.

