Amanpreet Kaur et al. International Journal of Recent Research Aspects ISSN: 2349-7688, Vol. 4, Issue 3, Sept 2017, pp. 54-58

# Fruit grading By Computer Vision- A Review

**Ramanpreet Kaur[1] Mukesh Kumar[2] Mamta Juneja[3]**

UIET, CSE Department, Panjab University, Chandigarh

*Abstract*- **With increasing demand of fruits of great quality at per safety standards, necessity for valid, speedy, unbiased class calculation of these characteristics in fruits pursued to arise. For producers, Fruit grading is an vital operation since it influence the export market and fruits quality assessment. It involves qualitative analysis of fruit considering both internal and external factors where internal factors involves the nutritive values, sweetness, aroma, flavor etc and external factors examine the fruit from visual inspection using shape, texture, size, color etc. Manual sorting and grading of fruits is slow, tiresome, error prone and needing large workforce, thus there is a requirement of a smart, self regulating fruit grading system. Researchers have unfolded various algorithms in latter years. This paper presents the relevant components of a computer vision system and emphasizes the important aspects of the image processing technique used in qualitative inspection of fruits by examining the external features of different fruits.**

*Keywords*—Computer Vision, Fruit Grading, Image processing, External fruit features

## I. INTRODUCTION

All manuscripts must be in English. These guidelines include In latter years, practice of image processing has been expanding day by day in distinct areas such as medical imaging, remote sensing, industrial image processing, transmission and encoding, texture classification, real time imaging, and object Recognition, etc. In agriculture, Image processing and computer vision is another emerging research field. From pre-harvest to post-harvest of crops, it is a vital tool and has large number of applications in agriculture [1]. Grading, sorting and classifying fruits using various features namely texture, size, color and shape etc has been done by computer vision and image processing techniques[2]. Fruits are selected and sorted according to quality and this is a costly and labour intensive task where consistency is difficult to maintain. Computer vision processing techniques can be used to automate the grading process, Back to its origin 1960s, its aim was to take over the place of human visual system. It is embedded in computers, which can be made to attain high-level understanding from the digital image or videos. It aims to get automated processes thus achieving the goal of speed and accuracy. Basically, it involves methods of acquiring, process and analyzing and getting high-level understanding from digital images.

The whole automated grading process consists of both standard hardware and software for its potential [3] working as shown in Fig.1. In case of hardware, combination of special lightening, mirrors and camera control techniques is used to obtain a computer image of the surface of each fruit. Software part involves algorithm and programs in grading process which includes image processing (preprocessing, region extraction, segmentation etc ) as well as classification criteria to grade the fruits into their respective categories ( like mature, under mature and over mature). Various classifiers are used namely Back Propagation Neural Network (BPNN), Probalistic Neural Network (PNN), Support Vector Machine (SVM), Artificial neural network etc.

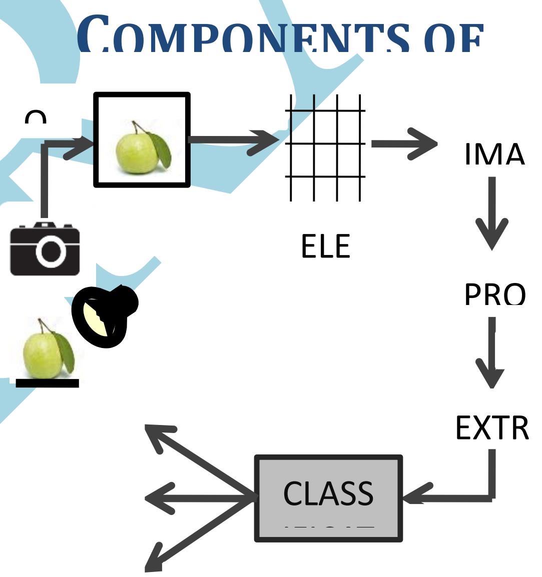


**Figure 1 : The Computer Vision's components**

**ASSESSMENT OF FRUITS**

Computer vision based fruit grading has been used widely since it is a non destructive and standardizes technique. It has potential to eliminate the tiresome monotonous inspections job. Kanali et.al,[4] described that with the use of computer vision for fruit grading results both in labour savings and improve inspection objectively.

**Banana**

Computer vision based study of banana has evoked much interest. It has been used for size calculation, maturity levels, quality grading. D.Surya prabha et.al, [6] had developed classification algorithm calculating the banana fruit maturity based on color and size features. This study make an effort to frame image processing technique to identify the maturity stage by color and size of the fresh banana finger image precisely. For color value extraction, mean(y) identifies the average color value of pixels in the image and it is defined as,

 

$$y = \sum_{n=0}^{l-1}\left(x_n t(x_n)\right) \quad \text{Eq.1}$$

Where '$x_n$' is the discrete variable representing intensity level in the image, $t(x_n)$ is the probability estimation of occurrence of '$x_n$' and l is the number of possible intensity value. Smoothness texture was measured using variance ($\mu_2$):

$$\mu_2 = \sum_{n=0}^{l-1}\left((x_n - y)^2 t(x_n)\right) \quad \text{Eq.2}$$

Smoothness texture 'R' is defined below,

$$R=\left(1 - \left(1/(1 + \mu_2(x) \;)\right)\right) \quad \text{Eq.3}$$

If R=0; image with constant intensity and if R=1; image with irregular intensity

Perimeter, area, minor axis and major axis are used to estimate size value of banana. Area is measured by entire count of pixels in the fruit region and whole number of pixels in the boundary region of fruit calculates the perimeter. Minor and major axis length is measured by using regional descriptors. Analysis of variance (ANOVA) with Duncan's multiple range test (DMRT) compares the significance of datasets. The datasets were analyzed using box and whisker plot technique.

Wei Ji et.al,[6] used ASDA ( the UK branch of US walmart) banana color chart in their experiment (Fig.3). This chart classifies the banana into following a) green b) light green c) more green than yellow d) equal green and yellow e) more yellow than green f) 75%yellow g) yellow, green tips h) yellow i) yellow with freckles. Major steps involved in image processing algorithm are color clustering and separation in CIELAB color space, evaluation of the average CIEXYZ of the banana skin, estimation of CIECAM02 colorfulness, lightness, hue composition, and interpolation of the H values to the ASDA ripeness grade. Euclidean distance is used to group the bananas.

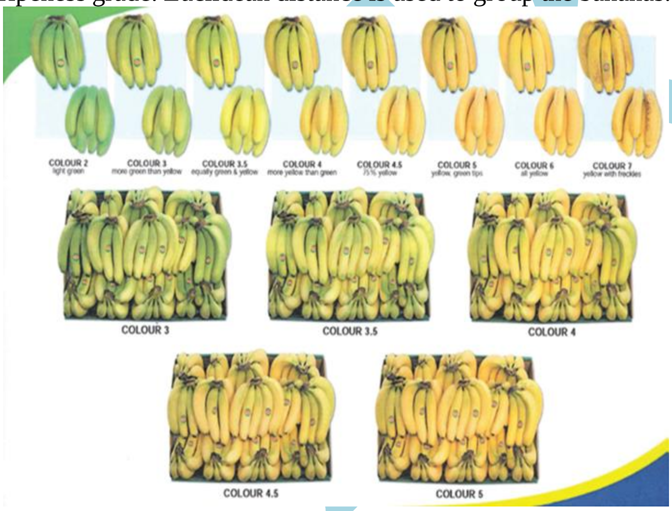


**Figure 2: Banana grade color chart presentating eight ripeness stages (supplied by ASDA) [7]**

Meng-Han Hu et.al,[7] determine size measurement of banana namely length, arc height and ventral straight length using computer vision based automatic algorithm. The Five Points Method is used as the key part of the automatic algorithm to site five points at the extremity of banana as shown in Fig.3.The three size measurement of banana with slightly curved, curved, and end-straight shape were determined using The manual method measures the slightly curved banana size, semi-automatic method estimate the curved banana, and automatic method measures the end-straight shape of banana finger.

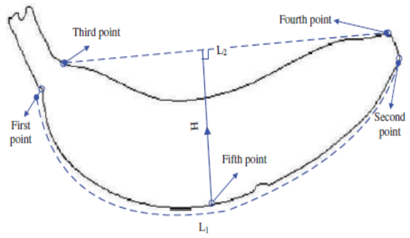


**Figure 3: Indicators of banana size [7]**

Alireza Sanaeifar et.al, [8] predicts the banana quality indices (titratable acidity total soluble solids (TSS), firmness, and pH as the output) from color features. It evaluated color of banana in L*a*b*, RGB and HSV color spaces and sent to Artificial neural network(ANN) and SVR (support vector regression) for calculating the quality indices. Association between quality indices and color components were scanned and the corresponding values are calculated like TSS value is low if the banana is greener, increased acidity is shown by riper bananas. The ripening process reduces the firmness while the banana has lower hue value (less chromatic).

**Apples**

Computer vision based apple grading has reflected the progress in fruit inspection. It has been used for jobs like defect detection, shape classification, quality grading and apple varieties. Apple can be classifies into two varieties based on image processing opinion– i) mono colored apples (e.g. granny smith, Golden delicious) ii) Bi-colored apples (e.g. Fuji, Jonagold). For second variety, Devrim Unay Bernard et.al,[9] presents a novel application for apple grading. In this work , image segmentation is followed by feature extraction. Features extracted are statistical feature of 1st order (mean, mode, median etc) , texture features of second order (sum of squares variance, contrast etc) and geometric feature ( defect ratio, circularity, perimeter). From various features extracted, subset of features are selected for classification of apples since using all available feature is computationally infeasible, classifier being used is SVM( Support vector machine) followed by Fuzzy K-NN.

Suresh M [10] classifies apple with 100% accuracy considering linear kernel function for the Support Vector Machine (SVM) classifier. RGB image of apples are converted into HSV image, and then threshold based segmentation is done on HSV image. For classification, average of red and green components is determined, average red color is plotted against green color as shown in Fig.4.

**Tomato**

Tomato quality is determined by its regular shape and managing defects and freedom from growt. Ruchita R. Mhaski et.al, [11] used color detecting algorithm for ripeness determination and edge detection algorithm is used to estimate shape and size of tomato. In color detecting algorithm, (i) if red color is detected from RGB image of tomato, then it is classified in high ripeness class (ii) If green color is detected, then it is low ripeness class (iii) If yellowish color is detected then it is medium ripeness class. Estimation of shape and size is done by dividing the image into contours. Area of each contour was compared, then finds the biggest among them and names it as the fruit size.

 

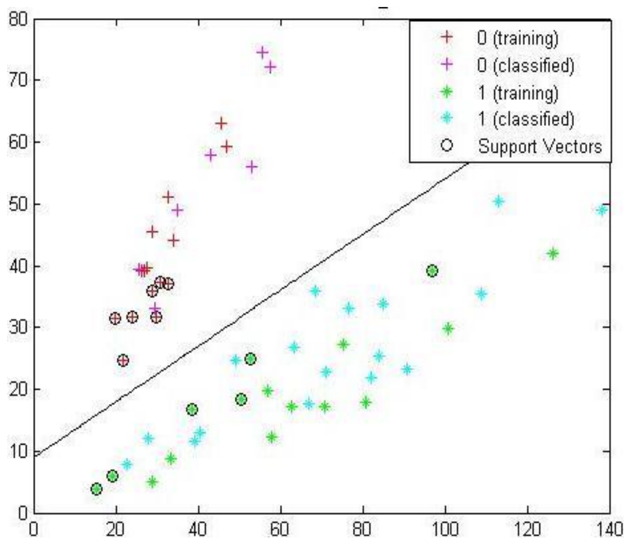


**Figure 4: SVM classifier [10]**

Megha. P. Arakeri et.al,[12] developed a quality evaluation method for tomato, consisting of both hardware and software. Image of tomatoes are preprocessed using median filter, and segmentation using Otsu's method resulting into image partitioned into two regions namely background and tomato region. From the resulted image, statistical and texture color feature for individual green (G), red(R) and blue (B) channels are extracted to detect whether tomato is defective or non defective.

- *Color Statistical features*

Color mean (μ) $= \frac{1}{N}\sum_{c=1}^{N} P_r$ Eq.4

Standard deviation (σ) $= \left(\frac{1}{N-1}\sum_{c=1}^{N}(P_r-\mu)^2\right)^{\frac{1}{2}}$ Eq.5

Skewness $= \frac{\sum_{c=1}^{N}(r-\mu)^3}{N\sigma^3}$ Eq.6

- *Color texture features*

Contrast= $\sum_{c,d=1}^{N}|c-d|^2 P_{cd}$ Eq.7

Correlation $= \sum_{c,d=1}^{N}\frac{(c-\mu)(d-\mu)}{\sigma^2}$ Eq.8

Energy= $\sum_{c,d=1}^{N}(P_{cd})^2$ Eq.9

Homogeneity= $\sum_{c,d=1}^{N}\frac{P_{cd}}{1+|c-d|}$ Eq.10

Ripeness is closely related to its color. The R, G, B value from image is extracted and averaged to following equation:

Mean R= $\frac{R}{N}$, Mean G= $\frac{G}{N}$ , Mean B= $\frac{B}{N}$ Eq.11

Where Mean R= average value of red channel, Mean G= average value of green channel, Mean B=average value of blue channel, R= red pixel, G=green pixel and B=blue pixel.

Feature extracted are fed to multilayer neural network which consists of a set of interconnected neuron to map the input features to the output and the classification is done with accuracy of 96.47%.

**Citrus Fruits**

J. Blasco et.al,[13] inspected peel defects of citrus fruits using region oriented segmentation, samples of different defects studied as shown in Fig.6. Citrus fruits used in this study are oranges and mandarins. Algorithm involves the preprocessing of image, seed selection, region growing iteration and finally region merging. At the end, detection of the defects has been done using region merged images.

M.khojastehnazhand et.al, [14] developed sorting system for lemon grading lemon based on size and color. From samples of different grades of lemon, information on the HSI color by estimating mean Hue(H) value for the fruit and volume is determined by spliting the fruit image into a number of distinct sectors, and then extracted value of color and volume are stored in database. During sorting phase, information is compared with information stored in database, the final grading of fruits is done.

**Miscellaneous**

Few other studies of computer vision linked with fruit grading are presented in this section. Ramya M[16] classifies mangoes into their maturity level using K-NN classifier, here mango image is divided into three region, then averaging R, G, B value extracted from RGB image using following equation.

$A_{K=R,G,B} = {}^{1}\!/_{r}\sum_{i=1}^{r}\sum_{j=1}^{c}(I_k \ * BW)$ Eq.11

Where BW= binary image acting as mask, $I_k$ = captured RGB image, r = no. of rows and c = no. of columns.

The K-nearest algorithm (KNN) estimates the distance between a query structure and a set of structures in the data set using Euclidean distance ($d_e$).

$d_e$(x, y)= $\sum_{i=1}^{N}\sqrt{x_i^2 - y_i^2}$ Eq.12

Yousef Al Ohali [16] drafted and implemented date fruit grading system which extract feature namely flabbiness, size, shape, intensity and defects and later use these for classification using Back Propagation Neural Network. Flabbiness is estimated by using color intensity distribution in the image, using relationship G(m, n)= C(m, n).R + C(m, n).G + C(m, n).B where R, G and B are the red, green and blue components of the pixel m, n in color image C, and G(m, n) is the modified gray level.

The size is estimated by number of pixels covering the fruit image. Using the mean area and variance relationship $\bar{A} \pm k\sigma^2$ , where $\bar{A}$ is mean of normalized area and $\sigma^2$ is variance, fruit are categorized as big, medium and small. Shape irregularity is used as a quality measure, edge tracking operator is used to estimate the shape. Better quality date produces high intensity images and is measured as $I = {}^{a}\!/_{A}$ where $a$ is area covering edges and $A$ is whole fruit area, $0 \le I \le 1$ The fruits are branded into three grade level by Back Propagation neural network.

Maley Kishore Dutta et.al,[17] classified grapes after pesticide exposure by extracting feature in frequency domain using Haar filter. Mean, Standard deviation and variance are statistical features of the second level wavelet decomposed ROI is used discrimate from treated and untreated grapes.

Hassan Sardar[18] estimated fruit quality of guava by color using updated Hassu algorithm to analysis quality of fruit . Proposed algorithm uses the image value to classify guava into respective categories.

*Image value*= $\frac{c_1 \times d_1 + c_2 \times d_2 + c_3 \times d_3 + \ldots\ldots\ldots c \times d_{255} * l}{c_1 + c_2 + c_3 + \ldots\ldots\ldots c_{255}}$ Eq.13

Where $c_i$ = no. of pixels belonging to color intensity of pixels Class interval (i.e. between 1 to 255 counted), $d_i$ = step deviation of range between color intensity of pixels class interval and

$l$ = length of Class interval in color intensity of pixels.

Summarization of the literature survey traced above is organized in Table 1.

 

**TABLE 1 : BRIEF SUMMARY OF DIFFERENT FRUITS AND ITS PARAMETERS**

| Name of Fruit | Author | Classifier used | Feature extracted | Performance parameters |
|---|---|---|---|---|
| **Banana** | D.Surya Prabha[6] | --- | Size, shape and color | Average color intensity algorithm – accuracy 99.1%<br>Area algorithm- accuracy 85% |
| | Wei Ji[7] | --- | Color | High coefficient of determination-.0.98 |
| | Meng-han Hu[8] | --- | Size | Mean value percentage difference for length and ventral length are 5.68 and 10.47% respectively |
| | Alireza Sanaeifar[9] | Artificial neural network | Quality indices ( pH, total soluble solids, acidity firmness, titratable based on color features) | $R^2$ values varies from 57 to 95%<br>RMSE- 13,6,0.04,0.2 for TSS, firmness, TSS,TA, pH respectively |
| **Apple** | Devrim Unay [10] | Support vector machine followed by Fuzzy K-NN | Statistical features(mean,mode,median)<br>Geometric features (size, shape)<br>Texture features( smoothness, pattern recognition) | 93.5% accuracy |
| | Suresha M[11] | Support vector machine | Color | 100% accuracy |
| **Citrus fruits** | J.Blasco [14] | --- | Defects | 95%accuracy |
| | M.Khojas-tehnazhand [15] | -- | Color and size | 86-100% accuracy |
| **Tomato** | Ruchita R. Mhaski[12] | -- | Shape, size, defect, color | Total processing time -0.89 sec |
| | Megha.P. Arakeri[13] | Multilayer neural network | Color, defect | 96.4% accuracy |
| Date | Yousef Al Ohali[17] | Back propagation neural network | Flabbiness, size, intensity, shape, defects | |
| Grapes | Malay Kishore Dutta[18] | Support vector machine | Pesticide treated and untreated | |
| Guava | Hassan Sardar [19] | --- | Size, color | |
| Mangoes | Ramya M[16] | k-NN classifier | Color | |




**Figure 6: Sample images showing defects studied [13]**

**CONCLUSION**

This review presents different computer vision based classification techniques for fruit grading and sorting system. Image processing is recognized as being the fundamental of computer vision with the evolution of more coherent algorithms helping in the significant implementation of this technique. The flexibility and non-destructive nature of this technique continue its attractiveness for application in the fruit grading. As per the analysis conducted, out of color, morphological and texture feature, morphological gave highest accuracy rate. In color model, HSI (Hue, Saturation, Intensity) color model is frequently used for grading because HIS color space is more precise in describing color. In machine learning techniques, PNN ( Probabilistic neural network) and SVM (Support Vector Machine gave highest accuracy.

 

## REFERENCES


[1] B. Erdenee, T. Ryutaro, G. Tana, “Particular Agricultural Land Cover Classification Case Study Of Tsagaannuur, Mongolia” ,IEEE International Geoscience & Remote Sensing Symposium (IGRASS), pp.3194-3197, 2010.

[2] J. K. Patil, R. Kumar, “Advances in Image Processing for Detection of Plant Diseases,” in Journal of Advanced Bioinformatics Applications and Research, 2(2), pp.135-141, 2011.

[3] Wang, H.-H., Sun, D.-W, “Correlation between cheese meltability determined with a computer vision method and with Arnott and Schreiber”, Journal of Food Science, 67(2), pp.745–749,2002

[4] Kanali, C., Murase, H., Honami, N. Three-dimensional shape recognition using a charge simulation method to process image features. Journal of Agricultural Engineering Research 70, 195-208,1998.

[5] D.Surya Prabha , J. Satheesh Kumar. “Assessment of banana fruit maturity by image processing technique”, J Food Sci Technol, 52(3), pp.1316–1327, 2015.

[6] Wei Ji, Georgios Koutsidis,Ronnier Luo,John Hutchings,Mahmood Akhtar, Francisco Megias, Mick Butterworth, “A Digital Imging Method for Measuring Banana ripeness”, Wiley Periodicals, 38(3), pp.364-374, 2012.

[7] Meng-Han Hu, Qing-Li Dong, Pradeep K. Malakar, Bao-Lin Liu, Ganesh K., Jaganathan, “ Determining Banana Size Based on Computer Vision “, International Journal of Food Properties, 18(3), pp.508-520,2015.

[8] Alireza Sanaeifar, Adel Bakhshipour, Migueldela Guardia, “Prediction of banana quality indices from color features using support vector regression”, 148, pp.54–61, 2016.

[9] Devrim Unay, Bernard Gosselin, Olivier Kleynen, Vincent leemans, Marie-France Destain, Olivier Debeir, “Automatic grading of Bi-colored apples by multispectral machine vision”, Computers and Electronics in Agriculture, 75, 204–212, 2011.

[10] Suresha M, Shilpa N.A, Soumya B, “Apples Grading based on SVM classifier”, International Journal of Computer Applications, pp.0975-8878, 2012 .

[11] Ruchita R.Mhaski, P.B. Chopade, M.P.Dale, “Determination of Ripeness and Grading of Tomato using Image analysis on Rasberry Pi”, International Conference on Communication, Control and Intelligent Systems, 978-1-4673-7541-2,2015

[12] Megha.P.Arakeri, Lakshmana, “Computer vision based Fruit grading system for quality evaluation Tomato in agriculture industry”, 7th International Conference on Communication, Computing and Virtualization,79, pp.426-433, 2016.

[13] J. Blasco, N. Alexios, E. Molto, “Computer vision detection of peel defects in citrus by means of a region oriented segmentation algorithm”, Journal of Food Engineering, 81, pp.535–543, 2007.

[14] M.Khojastehnazhand , M.Omid Tabatabaeefar, “ Development of a lemon sorting system based on color and size”, African Journal of Plant Science , 4(4), pp.122-127, 2010.

[15] Ramya M, Anitha Raghavendra, “Ripeness evaluation of mangoes using Image processing”, International Journal of Engineering Science and Computing, 6(7), 2016.

[16] Yousef Al Ohali., “Computer vision based date fruit Grading system : Design and Implementation”, Journal of King Saud University – Computer and Information Science 23, pp.29–36, 2013.

[17] Malay Kishore Dutta, Namita Sengar, Navroj Minhas, Biplab Sarkar , Arnab Goon, Kaushik Banerjee, “Image processing based classification of grapes after pesticide Exposure” LWT - Food Science and Technology, 72, pp.368-376, 2016.

[18] Hassan Sardar, “Fruit Quality Estimation by Color for Grading”, International Journal of Modeling and optimization, 4(1), 2014.


 