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Color, Size, Volume, Shape and Texture Feature Extraction Techniques for Fruits: A Review

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Abstract - *Grading and sorting of agricultural products such as fruits and vegetables are very important in post-harvesting process. In manual sorting efficiency totally depends upon the operators, so it is very time-consuming, costly, less efficient process. While exporting to market, quality of fruits must be very good. Grading of fruits is very important because it fetches a high price in a market. Grading and sorting are done based on the fruits size, color, volume, shape and texture. In this review paper, different methods of size, color, volume, and shape and texture detection are discussed. For color detection direct color mapping method, for volume detection water displacement method and Monto Carlo method, for texture detection Direct curvelet trans-form and Gabor wavelet transform, for shape detection Discrete wavelet transform, Fourier transform of a body, scale space, chain code and clustering methods are discussed.*

Key Words: **Grading, DCT, DWT, RGB, HSV, Sorting, Image processing.**

1 .INTRODUCTION

Agriculture has an important role in socio-economic development of India. Various types of fruits produced through-out the year. There are two parts pre-harvesting and post-harvesting. The post-harvesting process includes sorting and grading of fruits. In India, mostly fruit grading did manually. But manual grading is costly, time-consuming, inconsistent and less efficient. The export market demands high quality graded fruits. So there needs to develop a system which overcomes the problem of labor shortage, save time, and improve graded products quality. There are many factors based on that the grading of fruits is done. These factors can be classified into two type's external quality factor and internal quality factor. The external quality factors are size, shape, color, surface defects which can easily see with open eyes. But the internal quality factors are like aroma, test, flavors, sweetness, another internal quality factors[1] are vitamins, minerals, nutrients, carbohydrates present in that fruit. The sorting and grading based on size is easy process it can be done manually also but sorting and grading based on other external and internal factors is not possible with operators so there is need of automatic fruit quality inspection system which gives accurate result.

2. MOTIVATION

Sorting large of fruits manually is a time consuming process. As the sorting depend upon skill of particular person, skill varies from person to person so it is not accurate process Probability of error occurrences is more in manual sorting and cost is also high. To fulfill International market demand of fruits these agro industries must work with greater accuracy, more consistently and very efficiently. So automation is necessary in post-harvest process such as sorting and grading.

3. METHODS

Grading and sorting is done based on external and internal quality factors. The external factors are color, size, volume, shape and texture. There various methods used for color detection, size and volume calculation, shape, and for skin defect detection. But main condition is that the grading and sorting method must be nondestructive.

3.1 Feature Extraction Based on Color

Color is the most important parameter in defining the quality of any fruit. Color determines maturity of fruit. Most of the times consumer decision to accept or reject a particular fruit is depends upon its color. Most of the existing technology determines color of fruit by comparing the fruit color with the existing predefined reference colors [2].

Y. Wang et al (2010) [5] designed a system in which Fruit

quality inspection is done based on fruits surface color. It is nondestructive method of fruit inspection. Fruit image is taken first with camera; this image is in RGB color format. At next stage this RGB image is converted into the HSI color model. After that image is segmented based on hue value and then divide the fruit and its background. Then histogram of Hue and Saturation of fruits surface color is calculated. Back propagation network is designed, for this input is given as histogram output obtained earlier of Hue and Saturation of surface color of fruit. The Back Propagation gives the output as quality description of given tested fruit. Back propagation is three layer network used here. Training of Back propagation network is performed. They performed experiment on banana and result obtained is accurate.

Dah-Jye Lee et al.(2011) [2]designed a Direct color mapping technique for obtaining the color of fruit and based on that grading of fruit is done. In existing technology there is no such arrangement of adjusting color preferences or grading parameters as per application. Direct color mapping overcomes this problem, so it is user friendly technique. In this method, the given image of color space RGB. The color of interest is decided first from given range in this method for example tomato maturity steps are taken as example it varies from dark green to dark red, and in between that green, orange, light red .Then these preselected colors used to calculate a unique set of coefficients. These coefficients are used for color space conversion. The 3 dimensional RGB space is converted into a small set of color indices as per requirement of application.95% accuracy is achieved in grading application in variety of color fruits because of adjustment of color preference.

M. Dadwal and V.K. Banga (2010) [6] done a review on Fruit ripeness detection based on color image segmentation. Various techniques are available out of that Clustering algorithm, Histogram matching and parameter based segmentation are given in this paper.

Clustering algorithm: In that same elements are grouped together is called as clustering. All this is done step by step process that is called as algorithm. Here Clusters of similar color pattern are calculated. There are various partitioning clustering algorithm available [7] K- means; Fuzzy c means (FCM), Gustafson Kessel improved by Babuska (GK-B), and Gustafson Kessel Possobilistic Fuzzy c Means (GKPFCM). The method for performing this image is partitioned, clustering is performed of similar color pattern, and then distance is calculated in between a pixel and cluster center, it is squared or absolute difference. If spatial information is added in this then identification is more efficient [6].

Histogram matching: In this method first step is conversion of color image to grey image. Then histogram of grey image is taken. The database contain sample of histograms of ripe fruits. Then obtained histogram is compared with database samples and ripeness is detected [6].

Parameter based segmentation: According to [8] here RGB color space is used all the process is done on this original color image. First the value of Red Green and Blue are set for ripeness detection. For particular fruit particular color is selected for example if ripe tomato has red color and unripe have green color. So to detect ripeness of tomato only red color is segmented from the RGB color space. As per requirement color decided and based on some rules ripeness is detected.

Clustering algorithm is useful if the quantity of information is more it only depends upon type of distance. Histogram matching provides better result. Clustering algorithm and histogram matching both requires color transform. But parameter based segmentation not required color transform so this is efficient method for ripeness detection.

3.2 Feature Extraction Based on Size and Volume

The cost of many products is directly related to their size. The size calculation for regular shapes is easy, but it becomes more complex in fruits and vegetables with irregular shapes. Parameters used for size calculation are area, length, width and perimeter. Size can be calculated by various ways. In one-dimensional based on length and width. In two-dimensional based on area and perimeter and in three-dimensional using volume and surface area [3]. Fruits sorting and grading based on volume is very complex part as volume calculation is three-dimensional measurement [3].

H. Dang et al (2010)[17] developed a system for fruit size detection. This system is based on the image processing. The basic steps performed in this are image processing, then edge detection ,then fruit size detection and based on size grading of fruit is done. In image processing main step is filtering of image ,in this faster median filter algorithm is used for removing noise and because of that good edge is detected. In edge detection, first the image taken is converted into grey image. Then OSTU (maximum classes square error) is used to get binary image directly. For edge sequence detection 8-connected boundary method is used. Then fruit size detecting algorithm in order to calculate size of fruit. In order to calculate the diameter fruits natural symmetry is taken into consideration. From symmetry

center coordinate of fruits shape and axis in fruits image obtained. As center coordinate and axis are found , a line through center point which is vertical to line from axis point to center point. From this line diameter is calculated. For accurate result two edge points are searched. If fruit is rotated then also diameter shown is same then the diameter indicated true fruit size. Then based on accurate size grading is done [17].

Water Displacement method uses principle of Archimedes [3]. This method is used for food volume measurement in early years when no technology is available. Hardware required is jar showing contents of water inside it. The fruit is dropped into the jar and rise in water level is calculated. The difference between rise level and original level represents volume of that fruit. But drawbacks are, this process is time consuming and no guarantee that obtained result is accurate [3]. This method is destructive to a fragile object and if the product is porous it absorbs the water when dropped in the water so shown result is inaccurate. [3].

J.Siswantore et al (2014) [3] developed a monto carlo method. This method is used for irregularly shaped food volume measurement with heuristic adjustment. The hardware used for this a multiple camera for image acquisition, a computer, a light source and a black background as shown in Fig.1.

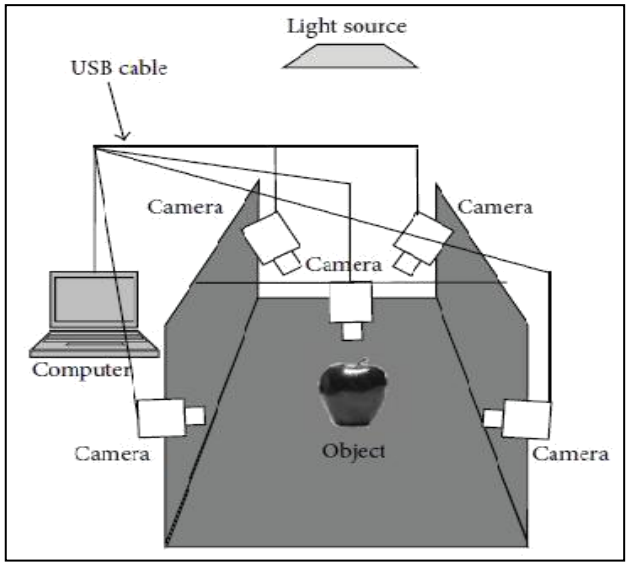

Fig -1: Camera Calibration systems [3][4]

Fig.2. shows the flow of Monto Carlo method. Then camera calibration is done. The main aim of camera calibration is to obtain extrinsic and intrinsic camera parameters from taken 2-D image. Intrinsic and extrinsic camera parameters transform a point in real world co-ordinate system to image co-ordinate system. Then in image acquisition the fruit is located on plane z=0 as shown in fig.1. As five camera placed at different position five images are taken of that fruit. The image is with RGB color space and in dimensions 640*480 and resolution 96dpi in vertical and horizontal direction [3]. In processing the image with RGB color space is converted to HSV color space. Because image segmentation is easy in HSV, fruit image can easily separate out from the background. Then in image segmentation is done .In that image is segmented into interested region and background. The image formed in image segmentation is binary image.Thresholding is applied here, one threshold is decided if the pixel grey scale value is greater that threshold then it assigns as binary 1(white) otherwise o(black)[3].

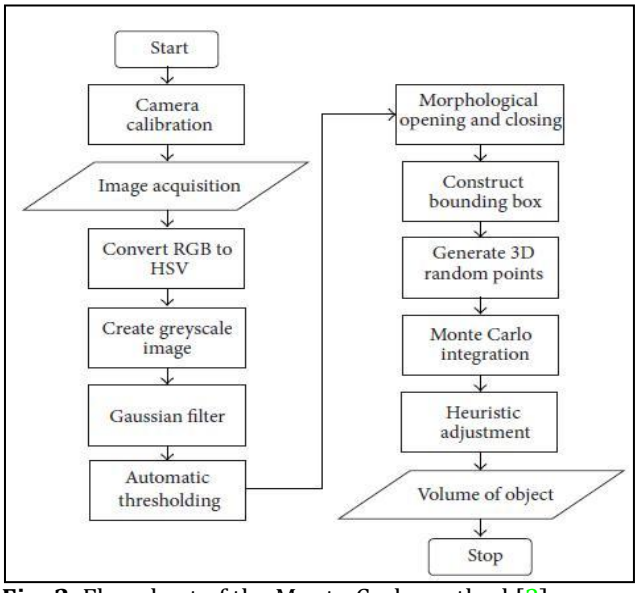

Fig -2: Flowchart of the Monto Carlo method [3]

Then in volume measurement, bounding box construction is first step in this determine 3D bounding box of measured object . From 3 D bounding box upper and lower co-ordinates of x, y, z direction, of real world coordinate system. The binary image and camera parameters help to determine bounding box. The main condition is that the measured object must be fit in the bounding box [3]. Then 3 D random points are generated. Then Monto Carlo integration is done to obtained volume. Various formulas are present for volume calculation then heuristic adjustment is done because five cameras are present to capture image. But problem facing is that the object point selected may be wrong it may present outside of object. If we consider wrong object point in volume calculation then obtain result is wrong so here heuristic adjustment method is applied for correct result of volume [3]. In validation each sample is measured three times and mean is calculated. Absolute relative error (ARE) and coefficient of variation were used to measure accuracy and precision [3].

Another method for volume calculation is color image segmentation method [4] in that different methods are available. In Region base technique image is divided into

different region based on some rule such that each region contains pixels with same grey scale value. In edge detection is generally used for detection of discontinuities boundary such as corners, lines and curves. In split and merge technique, split is performed when image is with too much variety. Split is performed with thresholding and In merge technique, two regions are joined together if they are similar and adjacent. There are different algorithms are also available for volume calculation such as image analysis algorithm and Canny edge detection algorithm [4].

3.3 Feature Extraction Based on Shape

Shape is also most important parameter for selection of healthy fruit. There are various method available for Fruit shape detection.

I. Discrete Wavelet Transform (DWT):- Image is made up of pixels. These pixel are arranged in two dimensional matrix form. Each pixel location represents digital equivalent value of image intensity. Wavelet is a function in Digital image processing and is mostly used for image compression [13].

II. Dipalee Gupta et al (2015) [9] developed a image compression technique by using Discrete wavelet transform. Here Discrete wavelets are used such as Haar Wavelet and Daubechies wavelet. It is used for compression in still image. Wavelets perform compression of image so that wavelets are formed and space required for image storage is reduced [13]. Wavelets have not uniform edges. They are able to provide better picture by removing noise pixels. In spatial domain the neighboring pixel value highly depends upon each other and therefore redundant. To compress image these redundancies between pixels must remove. Discrete wavelet transform converts spatial domain pixels into the frequency do-main, representation is in multiple sub-band format in different time scale and frequency points [13].

III. Fourier Transform of Boundary: - For shape description method uses Fourier transform of one dimensional boundary representation and Region based Fourier transform. In one dimensional Fourier descriptors, Fourier transform is applied on shape signature which is one dimensional function. Shape signature is derived from shape boundary coordinates. Fourier descriptors of the shape are normalized Fourier transformed coefficients [13]. In Region based Fourier descriptors performed in two steps, in first step the approximated normalized image counter clockwise rotated with very small angular step. Then in second step from the image center to the positive X-axis all pixel values are copied first and then pasted as row element in new matrix [13]. This all process repeated up to 360 degree [13].

IV. Scale space: - Scale space means dealing with image structure at different scale. Scale space is very good method for rep-resenting important object features. Low pass Gaussian filter with variable widths is applied to track the position of infection point in representation. The infection point remained in representation were significant object characteristics. Multiscale filtering helps to separate detail of shape properties [13].

V. Recognize boundaries of objects: - The image is two dimensional arrays. The array contains binary elements. Boundaries of object recognized based on starting point which is considered as single pixel on the object background interface. First interest point is selected like this and then for finding other pixels, moved in clockwise and anti-clockwise direction. The pixels searched diagonally. The object boundary can be recognized by hunting other pixels in a fixed direction [13].

VI. Clustering: - Clustering means grouping similar things together. The pixels in one group are more similar to each other than other group. Clusters contain group of pixels values with small variation [15].

VII. Chain code: - Different shapes such as line , drawings, planer curves can be identified with chain codes. It is lossless compression algorithm. For each region, the coordinated of any point on the boundary are transmitted. The encoder moves along the boundary, at each stage encoder transmits any symbol that represents direction of movement. This process continues up to when encoders return to starting position. Because of this blob is completely detected, and process continues for next blob detection [16].

3.4 Feature Extraction Based on Texture

The color recognition process is very important for ripeness detection. But instead of that fruits external surface defect detection is also an important process. For that texture analysis is useful.

S. A. khoje et al [10] developed a system of fruit grading for automated skin defect identification using Discrete Curvelet Transform. Texture analysis is mainly used for fruit quality detection. Texture analysis is done by Discrete Curvelet transform. Discrete curvelet transform uses multi resolution approach, based on that local and global features of that fruit with the help of low and high resolution capability of DCT are taken .Feature such as Energy, entropy, mean and standard deviation of each good and defected fruit is calculated. This four characters are used to characterize

fruits surface texture. The obtained features are then further given to Support vector machine and Probabilistic neural network for classification of good fruits and defected fruits. Based on obtained result SVM is more accurate than PNN [10].

H. Alimohamadi et al (2013)[11] designed a system for skin defect detection in fruits. For this they use a robust algorithm called Gabor wavelet Filter. For analysis of skin defect they first convert color image into texture image. And then on that obtained texture image Bank of Gabor filter is applied. Gabor Filter is linear filter and mostly used for edge detection. A filter bank consisting of Gabor filters with 4 scales and 6 rotations. From the response of Gabor filters image pixel is classifies as defected or normal skin. Optimal filter is chosen from bank of Gabor filters depending upon the response of Gabor filter. Last stage performed is thresholding the response of the optimal filter. Based on thresholding skin defect is detected. [11]

A. Majumdar et al (2009)[12] done a comparative study of curvelets , wavelets and contourlets. Curvelets, wavelets and contourlets used as a feature sets. Mostly used in pattern recognition. In this curvelets and contourlets are multi-resolution multidirectional transforms, they are used in face and character recognition [12]. Comparison result obtained is, for higher resolutions the wavelets used is a good option as a feature set for facial as well as character image. But as the resolution starts decreasing wavelets not work efficiently as feature descriptors. But at lower resolution curvelets work very efficiently. Contourlets not useful in higher as well as lower resolution, it only works in very coarse resolution. Recognition capabilities of all these three are tested using KNN classification [12].

4. CONCLUSIONS

This review paper analyses that, In India normally grading is done manually. The grading and sorting is mainly based on external and internal quality factors. The external factors are color, size, volume, shape and texture. Among these color and size are mainly used for features for grading of fruits. Grading based on Size is very easy method and less expensive method used for sorting of apples, tomatoes etc. In color based grading Direct color mapping technique is flexible and efficient method. For skin defect detection at higher resolution wavelets are used and at low resolution curvelets are best option. The grading based on size manually can be performed but result obtain are not accurate and grading and sorting based on other external factor is not possible to done manually. So there is need of automation in fruit quality inspection.

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