Features extraction methods for automatic non-destructive fruit grading – A review

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Abstract-- As population increases, demand for various fruits and vegetables are increased in India. Automation in agriculture is essential in increasing the productivity and economical growth of the Country, hence there exists a need for automated system for accurate, fast and quality fruits determination. For quality grading and sorting of fruits, researchers have developed several algorithms. Color, shape and texture are most significant features for identifying disease and maturity of the fruit. In this paper, algorithms for color, shape and texture features extraction are reviewed. The objective of the paper is to review color, shape and texture based grading algorithms, its components and current work reported on an automatic fruit grading system.

Keywords: grading; fruit; color; shape; texture; feature extraction

I. Introduction

Almost 17% of the world's population gets supported from agriculture. In India even 70% of the common man as well as agricultural labor depends on the agriculture. Agriculture sector contributes 17% of the total Gross Domestic Product (GDP) of India, which show its significance to Indian economy.

As the major source of national income, agriculture becomes the backbone of Indian Economy[1]. India is ranked among the top three in terms of production of various agricultural commodities such as fruits, vegetables, food grains etc. and has emerged as the world's largest producer of Mango, Banana and Coconut[2]. The global ranking of the country is 2nd in terms of the productions of the fruits and vegetables next to China[3]. The highest increase in the terms of production was detected in cotton which is >200 percent, was followed by the fruits and vegetables having 97 percent, condiments and spices having 66 percent and wheat has 39 percent in the last two decades. The fruit "mango" occupies the first position in production accounting 37.2 percent of the total area in TE 2009-10[4]. The national income of the country will directly increase if the overall production of fruits is good. Therefore to increase the production of agricultural industry, currently researchers are trying to develop innovative and automated methods using science and technology [5].

Due to advances in the computing technology image processing has the potential for application in agricultural processes where the guidance and grading is required [5]. Decision making for grading, fruit sorting etc. can improve through application of image processing as an analyzing tool in agriculture [6]. Image processing has been used as an analyzing tool in numerous applications of agriculture. Land or aerial remote sensing of crops, detection and recognition of pathological stress conditions, detection of disease in leaf, stem, fruits and vegetables, shape and color characterization of fruits, identification of affected area by disease and effect on productivity are few examples of these applications. In fact, Automate agricultural management tasks can be improve with quantification of the visual properties of horticultural products and plants [7]. Some of the specific applications are included:

- Image processing is an interactive distance diagnostic tool for the detection of disease, insects and other organisms in pest management [8].
- For Crop assessment also image processing can be used to detect Weeds, which are unwanted crops that compete with growing crops for water, light, nutrients and other spaces. Nowadays Remote sensing is most promising technique to detect weeds in crops [9].
- For quality inspection and grading for horticultural products, food products, grain classification and quality evaluation. Horticultural products can be apples, mangoes, banana, pomegranates, grapes, oranges, nuts, peaches, pears, tomatoes and potatoes [10].
- For Harvesting of fruits and vegetables image processing can be used [10].
- For identification of different diseases such as fungus, foliar leaf spot, and Alternaria leaf spot on cotton leaves [11].
- For estimation of plant nitrogen content using multi spectral image sensors [12].
- Real time object tracking using color and texture segmentation [13].

In the countries like China, Japan, and USA, much more research in field of agriculture is done as compared to India. Even though India produces fruits and vegetable in huge amounts then also it lacks in scientific grading systems. Generally, Human expert grade the fruits using hands and

eyes, which cause lack of neutrality, efficiency and accuracy. Most of the grading of fruits is based on size feature which is done manually in India. Hence, there is a need to automate grading process. Growing demand of low priced camera and computer makes automation more fast and accurate. Various image processing algorithms have been developed by researchers to improve accuracy of grading systems.

Image processing improves fruit quality and reduces the manual work of grading. One can extract features such as fruit shape, colour and size in a nondestructive way using fruit grading. One can even make standard rules as grading criteria and then machine performs grading automatically. Since supply of high quality products within a short time is ever-growing,automated grading systems of fruits are having special priority. Due to automatic grading systems grading can perform faster, it saves the time as well as manual labor. Numbers of automatic grading systems are available for different fruits such as for the Apples, Oil Palm Fruits, Strawberries, Citrus, Oranges, Mangoes, Lemons, Dates etc[5]. So feature extraction is most important part of any grading system. The objective of this study is to review some feature extraction techniques for shape, texture and color, which will in a way useful in automatic fruit grading.

Aroma, color, composition, defects, firmness, size, shape, maturity and odour are few parameters for non-destructive fruit grading. Even maturity indices for fruit includes flesh color, skin color and specific gravity (the ratio of the mango density to the density of water)[14].

Here in this paper we have reviewed methods for color, shape and texture features extraction. Paper is organized as follows. Begin with section 2 where different color feature extraction methods have reviewed, followed by shape and texture feature extraction in section 3. Finally in section 4 we have conclude the paper and showed the future work.

II. Color Feature Extraction

Feature is the concerned part in an image and feature detection is a low-level application of image processing. Do denote descriptor in pattern recognition, feature word is used in literature and main desirable property of feature detector is Repeatability [15]. Before doing color feature extraction, the first process one needs to do is segmentation. For the segmentation process, choice of the color space is also vital. RGB, YUV, HIS and CIE are various popular color spaces available in which one can do segmentation process [16]. Details of different color space can also be found in [19].

There are many ways available for doing image segmentation. Some of the image segmentation techniques are Histogram thresholding, Region based approach, Edge detection approach, Fuzzy approach and neural network approach [16]. More details on image segmentation techniques are provided in [17-18].

In [5], different color feature extraction techniques are reviewed, which contains dominant color method, intensity distribution method, mean of color, Nine color characteristic data, HIS and YES color model technique and discrete color mapping technique. This paper contains Merits and demerits of all these methods. Some basic fruit grading method based on different parameters are also explained in [20]. Authors have also explained different color feature extraction techniques with their accuracy in their review. Below table summarize the merits and demerits of some of the color feature extraction techniques.

Table I. Merits and demerits of color feature extraction techniques [5]

Technique	Merits	Demerits
Dominant Color Method	Nearer to human vision and grading accuracy increased	Little complex for computation
Intensity Distribution Method	Very easy to implement	High contrast expected in image
Mean of Color	Easy to implement and require less computational power	Not accurate
Nine Color Characteristic Data	More accurate	High Computation power required
HIS Color Model Technique	Due to Hue value, more stable in different lighting conditions	Color transformation to HSI required
Discrete Color Mapping Technique	Provide more accuracy and simple to implement	Conversion from 3D to 1D required

III. Shape and Texture Feature Extraction

One can define objects using texture or shape. Shape is graphical data that contains location, size and rotational effects while texture of an image gives us information about the image color or intensity. Even image segmentation can be done based on texture [21]. Structure and statistical approach are used in computer graphics to analyze image texture.

For counter based shape detection, different algorithms like Shape Signature, Chain Code, Fourier descriptors, Smooth curve approximation, Wavelet descriptors or Fractal dimension are explained in [22]. Contour Based Fractal Dimension is one of the best methods for shape or boundary detection of objects like leaf or fruit. Some Region based method like Medial axis or skeleton technique and Geometric moments are also explained in [22]. Geometric moments method gives good result because it provides much redundant information about an object's shape.

In [23], texture feature is extracted in RGB color space by combining group of pixels and change is measured in the value of pixels. If change is of less than 1% than that group of pixels are combined with other group to create texture. Same way texture is extracted from image based on group of pixels in [24]. Image is divided into small blocks and merged based on same values. Region based segmentation algorithm is used here. The proposed method is very fast.

Size, shape, color, freshness and absence of visual defects parameters can be used to evaluate shape in [25]. Review of different shape algorithms have been done for agricultural products in this paper. Here Objects Ratios and Shape Indices , Outline-Based Methods and Multivariate Analyses methods are explained where online based method gives 94% outcome.

Deformable shape detection and shape reorganization is performed in [26]. Minimum description length principal and deformable shape template is used to partition image. Proposed system is implemented and tested in color segmentation with 2D shape models and global information. Method has two stages here. First segmentation using traditional region segmentation algorithm and second deformable model based evolution and the use of statistical shape model to do prior probabilities on global for each object of class.

Fuzzy logic is used for geometric shape detection in [27]. Algorithm contains the steps like, image conversion into gray scale, finding object boundary by chain code, finding area, finding inclination of object, find bounding box and take ratio of inner part of object with outer part. This method gives almost 95% outcome.

Shape detection algorithm based on neural network is proposed in [28]. Study performed on Papaya fruit where "otsu" method is used for segmentation and noise removal is performed using morphological technique. According to algorithm shape classified into 4 different size namely S(small), M(medium),L(large) ,XL(Extra-large).This method provides 94% accuracy in shape detection.

Pre-defined pattern is derived from shape, color and texture of an image [29]. Paper contains study and review of many different techniques used for feature extraction and texture classification. The objective of study is to find technique or combination of techniques to reduce difficulty while increasing the accuracy of shape detection at the same time. Paper contains review of three feature extraction methods: Gray Level Co-occurrence Matrix-GLCM, Local Binary Pattern-LBP and Gabor filter method-GFM. Also two classification methods KNN and SVM are used on the texture datasets Brodatz, CUReT, VisTex and OuTex for the experimental purpose.

Image processing and pattern recognition techniques are covered in [30], which will be useful to analyze bio-images. Image pattern recognition is the technique to classify an input image into one of the Pre-defined classes. Paper contains two main modules, that is, feature extraction module and classification module.

Mango fruit detection algorithm is presented in [31]. They have used Randomized Hough Transform algorithm to find potential places of mango in images. By using Back propagation Neural Network, they find mango from these potential places. 70 RGB images are captured from mango fruit from tree for dataset. The detection rates up to 96.26% is achieved. Result decreases in the case of partially covering or overlapping.

Shape based technique using hybrid Fourier descriptors (FD) and spatial domain analysis (SDA) is explained in [32]. Shape boundary representative:1.complex-valued signature (CVS) or real-valued signature(RVS) are used for boundary detection where cvs divided in two types (i) centered based complex coordinates and (ii) non-centered based complex coordinates. During training process artificial neural network (ANN) system is used in the recall phase in accurately detecting the color of such a fruit. ANN has been used for color sorting and identification. Highest classification accuracy of 99.1% was obtained in this work.

Two approaches for fruit grading are proposed in [33]. There are two approach- In first method tries to distinguish between two different images by extracting features related to the intensity among pixels and their neighbors. Second approach is to retrieve the variances of intensity between pixels. To enhance further, different features of color, shape, texture and size are combined together to improve the performance of the detection. Using color, shape and size-based features combined together to increase the accuracy of recognition. So accuracy up to 90% has been achieved.

Texture classification based on random projection is performed in [34] which is suitable for large texture database applications. A small set of random features is extracted from local image patches. After that process the random features are embedded into a bag-of-words model to perform texture classification. In this paper experiments on each of the CUReT , the Brodatz, and the MSRC databases have been performed. They have compared the proposed approach to four state-of-the-art texture classification methods: Patch, Patch-MRF, MR8, and LBP.

Shape and vein, color, and texture features are used to classify objects and Probabilistic Neural network (PNN) was used as a classifier in [35]. The experimental result shows that the method for classification gives average accuracy of 93.75% when it was tested on Flavia dataset, that contains 32 kinds of plant leaves.

Similarity criteria and similarity metric is used for shape

based classification in [36]. Apple grading system on European standards is performed in [37]. 1000 images of apple fruits are taken for experiments. Color feature extraction is done for grading. 78% accuracy is achieved in this paper. Below table summarize merits and demerits of some shape and texture feature extraction techniques.

Table II. Merits and demerits of shape and texture feature extraction techniques [38]

Technique	Merits	Demerits
Circular Hough Transform	Handle missing data and easy to implement	Computation power depends on object and very complex for object with many parameter
Discrete Wavelet Transform	Work in spatial as well as frequency domain	Loss of generality
Fourier Transform of Boundary	Easy to implement	Does not provide local shape information
Probabilistic Neural Network	High Accuracy	Detect noise as a texture
Chain Code	Less storage volume	Loss of generality

IV. Conclusion and Future Work

Automatic non-destructive fruit grading is very important for agriculture sector. India is currently lacking in the same. Color, shape and texture are the vital features for grading of the fruits. Here in this paper some of the techniques for the color, shape and texture features extraction are reviewed. We still suffer from quality issues even though we are having such a high rank in production of fruits and vegetables. If automatic grading systems are available then it would save the time as well as the manual labor. And most important their quality can be judged.

As India is not having such automatic grading system, development of such grading systems, which could economically help the agriculture, can be planed. Different color, shape and texture features extraction techniques can be used for different kinds of fruits and vegetables. Some advantages and disadvantages are explained in section 2 and 3. Different new algorithms can be created for the grading task. Advantages of different techniques can be combined to improve the accuracy and efficiency of grading in future.

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