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A Proposed Method for Fruit Grading from Fruit Images using SVM

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Abstract- Agriculture is the largest economic sector and it plays a major role in economic development of India. The manual classification and grading techniques of fruits are distinguished between different types of fruits. Many new technologies are developed by researchers but enhance method is still needed. This paper presents a method for fruit grading from fruit images using image processing and machine learning techniques.

Keywords: Fruit grading , Fruit images, SVM, Classification and Machine Learning Approach

I. INTRODUCTION

Fruits are delicate materials, so they should be tested via non-destructive techniques. Classification is vital for the evaluation of agricultural produce. Fruit size and shape are the most important physical property while colour resembles visual property. Hence, classification of fruits is necessary for evaluating agricultural product, quality standards and market value. It is also helpful in planning, packaging, transportation and marketing operations. If the classification and grading is done through manual techniques, the process will be too slow and sometimes it will be prone to error. If colour, size, shape etc. i.e. quality measures are mapped into an automated system then the work will be faster and error free.

The proposed automated classification and grading system is designed to combine three processes such as feature extraction, classification and grading. Software development is highly important in this colour classification system. The entire system is designed using Mat lab Software to inspect the colour, shape and size of the fruit. Colour of the fruit is very important in classification but since due to the similarity of colours between fruits, the size and shape also helps in solving this kind of problems. The colour, shape and size based classification involves extracting the useful information from the fruit surface and classify it to the respective type.

This paper proposes a method for fruit grading from fruit images using image processing and machine learning techniques. The goal of the system is to separate the fruit images having same type of features into one category from a set of fruit images given as input to the system. Image Pre-Processing techniques such as noise removal and contrast enhancement are used for improving the quality of image. It makes suitable for further processing. Feature extraction methods such as Geometric feature extraction is used for extracting the geometric shape, area, parameter of the pre-processed images. Colour features extraction method is used for extracting colour features like number of red pixel, number of yellow pixel etc. present in the pre-processed images. Support Vector Machine (SVM) classification method is used for separating same type of images into one specific group. The performance of the trained SVM classifier is also tested on a test set of fruit images. The trained SVM classifier in the proposed method is high classification accuracy and is also suitable for correctly identifying the images having same type of features.

Section I contains the introduction of the paper. Section II discusses the related work. Section III presented the methodology with block diagram. Section IV describes results and discussion. Section V contains concluding part of the paper with future scope.

II. RELATED WORK

Researchers state that simultaneous fruit sorting by size and colour would save time, reducing fruit handling [1]. In some works, the operations and performance of an automated quality verification system for agricultural products are its main features[2]. For the greater number of the fruits, colour is associated to the physiological ripeness and can be used as a sorting pattern. Some researchers report that the surface colour of tomato is a major factor in determining the ripeness of this fruit[3]. The system used improved engineering designs and image-processing techniques to convey and grade products. Surface inspection had been accomplished through processing of colour CCD images while internal inspection employs special sensors for sugar and acid content. An X-ray sensor was incorporated to detect biological defects. Another paper[4] presented a fruit size detecting and grading system based on image processing. After capturing the fruit side view image, some fruit characters were extracted by using detecting algorithms. Experiments showed that this embedded grading system had the advantage of high accuracy of grading, high speed and low cost. It was expected to have a good prospect of application in fruit quality detecting and grading areas. Polder et al. 2002 used principle component analysis (PCA) in conjunction with spectral imaging to grade tomato fruits according to their ripeness level[5].

Researchers had used colour as most striking feature for identifying disease and maturity of the fruit. In this paper; efficient algorithms for colour feature extraction are reviewed. Then after, various classification techniques are compared based on their merits and demerits. The objective of the paper is to provide introduction to machine learning [6] and colour based grading algorithms, its components and current work reported on an automatic fruit grading system. Researchers present an integrating system for grading by considering different attributes. A fruit colour, size detecting, and grading system based on image processing. Weight of fruit is used as a design metric to find out grading in food processing. Grading using weight as a parameter the load cell arrangement can be used. Machine learning and computer vision techniques have been applied for evaluating food quality as well as crops grading. Different learning methods are analysed for the task of classifying infected/uninfected Orange fruits from images of their external surface. Linear discriminant analysis[7] is then used to transform the feature space after feature fusion for better reparability, while three classifiers, naive Bayes, k-nearest neighbour and supported vector machines, were investigated.

II. METHODOLOGY

At first, the images of fruits are pre-processed. Then, several features are extracted from pre-processed images. The extracted features are fed into a Support Vector Machine (SVM) classifier in the form of a feature matrix. The classifier is trained. A new set of fruit images are tested by the trained classifier for performance evaluation. The block diagram of the proposed system is shown in Figure 1.

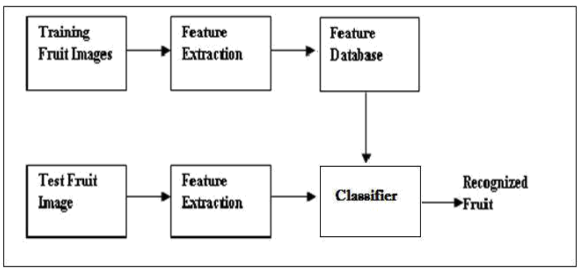

Figure 1: Block diagram of the proposed system

Pre-Processing is a common name for operations with images at the lowest level of abstraction- both input and output are intensity images. The aim of Pre-Processing is an improvement of the image data that suppresses unwanted distortions or enhances some image features important for further processing.

Pre-processing is the step taken before the major image processing task. The problem here is to perform some basic tasks in order to render the resulting image more suitable for the job to follow. In this case it may involve enhancing the contrast, removing noise. Pre-processing can dramatically improve the performance of image processing methods like Image transform, Segmentation, Feature extraction and Classification. Several techniques have been used to enhance images.

Pre-processing images commonly involves removing low-frequency background noise, normalizing the intensity of the individual particles images, removing reflections, and masking portions of images. Image pre-processing is the technique of enhancing data images prior to computational processing

.

In the proposed method, 25 digital fruit say, apple fruit images are taken for training the SVM classifier. At first some Pre-processing tasks are required to be done on the input images as mentioned above. This includes normalizing the images, colour conversion from RGB to Grayscale, resizing the images, removal of noise from the images, contrast enhancement for improving image quality, conversion of digital image into binary images, complement of binary images, filling holes of the images, eroding binary images and get clear boundary of the images.

The original raw input images are normalized in the range [0, 1], resized to 256 X 256. In image processing, normalization is a process that changes the range of pixel intensity values. Applications include photographs with poor contrast due to glare, for example. Normalization is sometimes called contrast stretching or histogram stretching. In more general fields of data processing such as digital signal processing, it is referred to as dynamic range expansion. The motivation is to achieve consistency in dynamic range for a set of data, signals, or images and also Principal Component Analysis method cannot be applied on un-normalized images.

The normalized RGB images are then converted into Grayscale images. Colour images are often built of several stacked colour channels, each of them representing value levels of the given channel. For example, RGB images are composed of three independent channels for red, green and blue primary colour components. Grayscale images are used just one channel of colour. It is relatively easier to deal with (in terms of mathematics) a single colour channel than multiple colour channels.

SVM classifier cannot be trained using images of different dimensions, hence the grayscale images are resized into 256 X 256 The most obvious and common way to change the size of an image is to resize or scale an image. The content of the image is then enlarged or more commonly shrunk to fit the desired size. But while the actual image pixels and colours are modified, the content represented by the image is essentially left unchanged. We have to resize all the images in a particular size. It is relatively easy to deal with (in terms of mathematics) same size images. Also resizing images improves efficiency in implementation and reduces runtime overhead.

Noise removal: Image noise is random variation of brightness or colour information in images, and is usually an aspect of electronic noise. It can be produced by the sensor and circuitry of a scanner or digital camera.

Noise reduction is the process of removing noise from the input image. The goal is to remove the noise from the image in such a way that the original image is discernible. We have to used two-dimensional Gaussian Filter for noise removal. A Gaussian Filter is used to smooth the image by calculating weighted averages in a filter box. It is more effective in smoothing images than normal mean filter.

Improvement of image contrast: Adaptive Histogram Equalization technique is used after noise removal for improving image contrast. Image enhancement techniques have been widely used in many applications of image processing where the subjective quality of images is important for human interpretation. Contrast is an important factor in any subjective evaluation of image quality. Contrast is the difference in visual properties that makes an object distinguishable from other objects and the background. In visual perception, contrast is determined by the difference in the colour and brightness of the object with other objects. Here we are using adaptive histogram equalization to enhance contrast. Histogram Equalization increases the dynamic range of the histogram of an image and intensity value of pixels in the input image. The output image contains a uniform distribution of intensities and increased contrast of an image than the original image. Adaptive Histogram Equalization differs from ordinary histogram equalization in the respect that the adaptive method computes several histograms, each corresponding to a distinct section of the image, and uses them to redistribute the lightness value of the image. It is therefore suitable for improving the local contrast.

Conversion to Binary Image: Converting to binary is often used in order to find a Region Of Interest -- a portion of the image that is of interest for further processing. The intention is binary, "Yes, this pixel is of interest" or "No, this pixel is not of interest“.

Complement of Binary Image: In the complement of a binary image, zero becomes one and ones become zero. In the complement of an intensity or RGB image, each pixel value is subtracted from the maximum pixel value supported by the class and the difference is used as the pixel value in the output image. In the output image, dark areas become lighter and light areas become darker. The following will be the notation used in the proposed method.

1. Filling Holes: A hole is a set of background pixels that cannot be reached by filling in the background from the edge of the image.
2. Eroding Image: By eroding an image we can get clear boundary between the desired portion and the background of an image.
3. Get Boundary Image: Get the clear boundary region of the image.

Figure 2 (a), (b), (c), (d), (e), (f), (g), (h), (i), (j) and (k) show an apple fruit image and pre-processing images after performing the above process respectively.

Figure 2: (a) Image of apple fruit before Pre-processing

Figure 2: (b) Image of apple fruit after Normalization

Figure 2: (c) Image of apple fruit after Color Conversion

Figure 2: (d) Image of apple fruit after Resizing

Figure 2: (e) Image of apple fruit after Noise removal

Figure 2: (f) Image of apple fruit after Contrast enhancement

Figure 2: (g) Image of apple fruit after Binary conversion

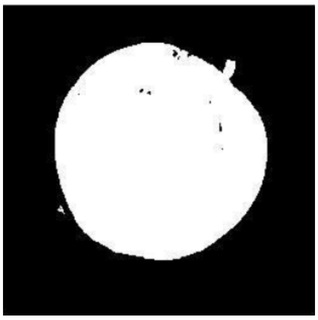

Figure 2: (h) Image of apple fruit after Complementing Binary conversion

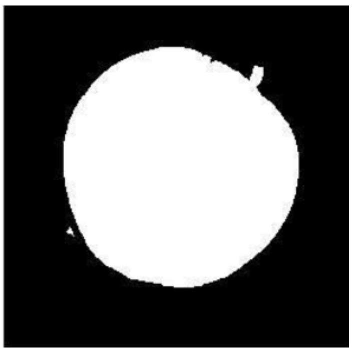

Figure 2: (i) Image of apple fruit after Filling holes

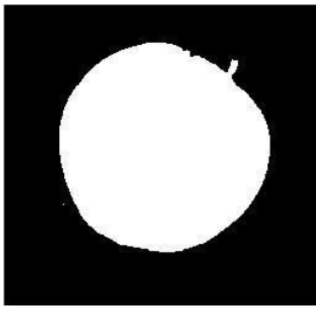

Figure 2: (j) Image of apple fruit after Eroding image

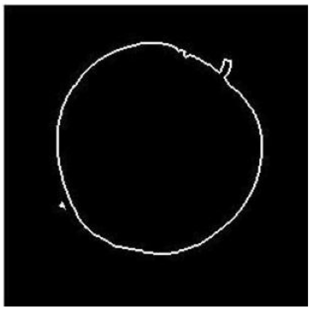

Figure 2: (k) Boundary Image of apple fruit

Feature Extraction is the process by which certain features of interest within an image are detected and represented for further processing. It is a critical step in most computer vision and image processing solutions because it marks the transition from pictorial to non-pictorial (alphanumerical, usually quantitative) data representation. The resulting representation can be subsequently used as an input to a number of pattern recognition and classification techniques, which will then *label*, *classify*, or *recognize* the semantic contents of the image or its objects. The process of *measuring* or *calculating* or *detecting* the features from the image samples. The most common two types of feature extraction are:-

1. Geometric feature extraction
2. Colour feature extraction

In Geometric feature extraction we can extract the geometric features like major axis, minor axis, area and perimeter of the images and assign these feature values into the morphological feature matrix. In Colour feature extraction we can extract the number of red pixel, number of yellow pixel from the images and assign these pixel count values into the colour feature matrix.

A classification task usually involves separating data into training and testing sets. Each instance in the training set contains one target value (i.e. the class labels) and several attributes (i.e. the features or observed variables). There are various approaches for image classification. Most of classifiers, such as maximum likelihood, minimum distance, neural network, decision tree and SVM require a training sample. On the contrary, clustering based algorithm, e.g. K-mean, K-NN or

ISODATA are unsupervised classifier, and Fuzzy-set classifier are soft classification providing more information and potentially a more accurate result.

SVM classifier is used for classifying the fruit say apple images into proper category. The goal of SVM is to produce a model (based on the training data) which predicts the target values of the test data given only the test data attributes. SVM is designed to separate a set of training images into two different classes, $(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)$ where $x_i \in R^d$, the d-dimensional feature space, and $y_i \in \{-1, +1\}$, the class label, with i=1…..n.

SVM builds the optimal separating hyper planes based on a kernel function (K). All images, of which feature vector lies on one side of the hyper plane, belongs to class -1 and the others are belong to class +1. Simplest type of SVM is Linear SVM, in which the training patterns are linearly separable.

RBF kernel generally performs better than other kernel functions when number of observations is larger than number of features. Linear kernel performs better than RBF kernel when number of features is larger than number of observations. Polynomial kernels are well suited for problems where all the training data is normalized. Proper selection of kernel parameters is necessary for achieving very high accuracy of classification. In our proposed method, we have compared performances of the above mentioned kernels for training the SVM classifier.

The images of different classes of apples are obtained from the world wide web. 64 such images are used as inputs to our proposed system. This set of 64 images contains,23 images are apples of CATEGORY-A, 19 apples are of CATEGORY-B and 22 apples are of CATEGORY-C. After pre-processing steps, 4 morphological and 2 colour features, i.e., a total of 6 features are extracted from these images and fed into SVM classifier for training and testing purpose.

Table.1

Kernel Function	Accuracy %	Sensitivity %	Specificity %	NPA %
Polynomial	84.6	80	95.83	88.46
Linear	51.2	86.67	33.33	80.00
MLP	48.72	3.33	41.67	71.43
RBF	76.92	73.33	91.67	84.62

III. RESULTS AND DISCUSSION

SVM in the paper has been used with the four prime kernel functions, namely, Polynomial kernel, linear kernel, MLP kernel and RBF kernel. With these kernel functions, the accuracy, sensitivity, specificity, have been calculated. Comparing the different results obtained using the different kernel functions, it was found that SVM with POLYNOMIAL kernel gave the highest accuracy of 84.6%. Performance of the different classifiers can be estimated using the following parameters:

Accuracy Rate – Correctly classified samples/Classified Samples

$$\text{Accuracy} = \frac{TP + TN}{TP + FP + TN + FN}$$

Sensitivity – Correctly classified positive samples / True positive samples

$$\text{Sensitivity} = \frac{TP}{TP + FN} \times 100$$

Positive Predictive Accuracy (PPA) – Correctly classified positive samples/ Positive classified samples

$$\text{PPA} = \frac{TP}{TP + FP}$$

Negative Predictive Accuracy(NPA) – Correctly classified negative samples / Negative classified samples

$$\text{NPA} = \frac{TN}{TN + FN}$$

Here, sample denotes input images used for training the classifier. The results for kernel functions used in training the SVM classifier are shown in Table 1.

Table 1: Performance comparison of kernel functions used in training the SVM classifier

In this paper, SVM classifier is trained using different kernel functions. From experiment, it is observed that using Polynomial Kernel, SVM classifier can achieve highest accuracy of 84.6 % after training. . So we have used the cross validated trained classifier using Polynomial kernel for the further testing on new apple images. Performance testing of this trained classifier is done on 39 apple images (15 Category-A, 11 Category-B and 13 Category-C) which were not in the set of input images used for training. The SVM classifier can successfully classify this test set with accuracy of 84.6%, specificity of 95.8%, sensitivity of 80%, positive predictive accuracy of 92.3% and negative predictive accuracy of 88.4%. it is shown in figure 3 along with bar graph in figure 4.

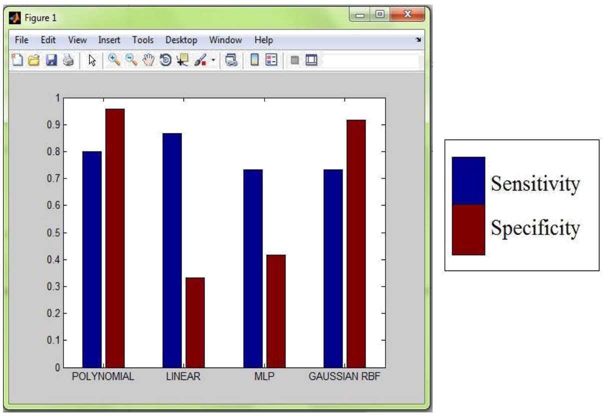

Figure3: Bar graph showing Sensitivity and Specificity after applying SVM on test images

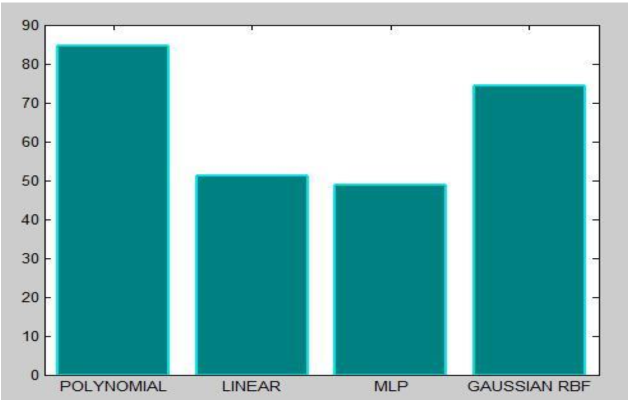

Figure 4: Bar graph of the accuracy of different kernel functions

V. CONCLUSION AND FUTURE SCOPE

In this paper, a system has been developed which can automate classification of apples of different categories from predefined apples of the different classes. Support vector machine classifier has been used for the purpose of classification. The computational efficiency of SVM is great, with only a few minutes of runtime necessary for training. A very good feature of SVM is that only a small training set is required to output significantly good results, because it is only the support vectors that are of primary importance during training. For these reasons, SVM tends to perform better than other supervised learning methods .

The four kernel functions used are : Polynomial ,Linear, MLP, RBF. Polynomial kernel outperformed all the other kernels and highest accuracy of trained classifier so achieved is 84.62%. Hence it can be concluded that our proposed method is very much efficient for automated detection of poorer quality of apples and also computationally very fast. This method is intended to help the horticulturists and cultivators, as well as exporters in their decision making, branding and pricing processes; by freeing them from the burden of time consuming manual checking of apples, and other fruits in general. Genetic algorithm may apply for better results.

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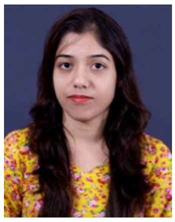
Authors Profile



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