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A Computer Vision Based System for Classification of Chemically and Naturally Ripened Mangoes

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Abstract*: Recently there was news indicating that mangoes might cause cancer. The news was based on the fact that mangoes were being artificially ripened using a chemical- calcium carbide and Ethrel, a well- known carcinogenic. The consumers hence have to be careful in buying the mangoes. In this study, we have proposed a model for classification of artificially and naturally ripened mangoes using k-NN and SVM classifiers. In order to improve the efficacy of the model, color space features such like RGB, HSV, L*a*b are extracted. Along with the color space features, 14 Haralick texture features are also extracted here. An mango is automatically segmented in an image using modified K-means clustering segmentation method. For the experimental study, mangoes of 2 varieties such as Badami and Raspuri have been taken. In each variety, three different classes of ripened mangoes are taken such as naturally and in chemical, two artificial ripening treatments were applied like calcium carbide and Ethrel solution. The obtained experimental result in terms of F-measure is ranging from 64% to 84% for two different varieties of mangoes using two different chemicals. Further this proposed model can be implemented for different variety of mangoes.

***Keywords*: Calcium carbide; Ethrel; SVM; KNN.**

I. INTRODUCTION

Health is getting poor as the world becomes wealthy. So everybody wants to consume fruits. Fruit ripening is a natural process and nowadays any fruit can also be processed or ripened with the ripening agent like Calcium carbide and Ethrel. India is one of the largest mango producers and exporters worldwide. Reacting to the widespread use of calcium carbide(CaC_2) to hasten the mangoes ripening process, food technologists and doctors concluded that the compound was unsafe and unfit for use in any quantity[5]. Calcium carbide also includes traces of arsenic and phosphorus hydride with carcinogenic properties[1][5]. Calcium carbide has many uses in the chemical and steel industries. Although this is prohibited, it is also used as a ripening agent in many countries such as India, Pakistan, Bangladesh, Nepal etc. It produces acetylene gas when reacting with water, which is an analog of ethylene gas and accelerates the ripening process[5]. Because of the moisture in the fruit, it produces heat and acetylene which helps to ripen faster. Calcium carbide ripened fruits are too soft and less savory[5].

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Ethrel solution which is also named as Ethephon is another ripening agent which also affects to human health, but this ripening agent has also been considered better than Calcium carbide, as it takes short time for ripening.
Ethrel ripened fruits have a more suitable color than naturally ripened fruits and have longer shelf life than calcium carbide ripened fruits [1]. Ethrel in aqueous solution is converted into ethylene bi-phosphate ion and chloride ion. Effect of ethrel spray on the ripening behavior of mango is discussed[2]. An artificially ripened fruit would have a yellow outer skin, but tissues inside would remain raw and green [5]. The need of the hour is to train end users and help them in identifying artificially ripened fruits. Such fruit intake can affect the skin, liver, lungs, small intestine, along with other neurotoxic effects as well [5].

Calcium carbide is extremely eye irritating and direct contact can even lead to blindness. It causes extreme discomfort on skin contact and rashes with burns. mental confusion and even seizures [3]. As the health problem increases day by day because of the consumption of chemically ripened fruits, it is necessary to carry out the subjective analysis for identifying chemically ripened fruit [4]. Developing a system for classification of naturally and artificially ripened mangoes is a difficult task because of less interclass and large intra class variations. In a real environment, when we capture the mango images in the fruit market or shops using a camera, where the resolution of the camera varies along with the variation in the distance between the camera and the mango. Also there is a lot more variation in the view points. Further, to make the classification task easier, only mango region has to be segmented by removing the background. Automation of mango classification is very essential at the export level because many countries had banned Indian mangoes since Indian mangoes were treated with chemicals for ripeness and also this model should be reachable to common layman at the market level. Identifying chemically treated mangoes may be possible for experts like fruit sellers but it is very difficult for common layman since they will not be having any knowledge about the features of the chemically ripened mangoes. However, there is no much work on Mangoes done to assess the issues and recognition of artificial ripening. The presence of chemically ripening agent is usually experienced on the fruit skin may be in the form of color or texture. Chemically matured mangoes also have distorted wrinkles on the skin [5]. On the skin of naturally ripened banana, dark yellow and small brown/black spots are seen; and their stalk being black [6].

But chemically ripened bananas have clear lemon yellow without black spots and their stalks are green in color. These fruits are soft, poor in flavor and shorter shelf life [7]. Analyzed ripening agents and change in nutritional parameters on artificially ripened banana samples [8].
There are some non-destructive methods to assess the fruits quality such as computer vision, near infrared spectroscopy and multispectral/ hyperspectral imaging[9].
Anoopa Ravindran.et.al [1] have addressed a detailed review on various artificial fruit ripening which is being used currently.

II. PROPOSED METHODOLOGY

In the proposed method, the defect free images are identified and are considered for preprocessing. After preprocessing, segmentation should be done to extract only the mango region. Further, the most dominating features such as color and texture features are extracted from the image to form the feature vector and later feature vector are fed to the classification model to classify the samples. Some percentage of samples has been used for training the classifier and remaining percentage samples has been used for testing the proposed model. Since the entire processing is done with the help of images (of fruit under test) the light intensity in which image is captured varies for different environment, capturing angles and zooming levels.

The flow diagram of the proposed method is shown in fig1.The following sections describe each step in details.

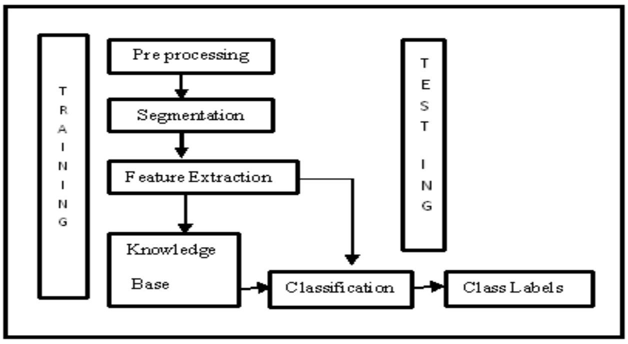
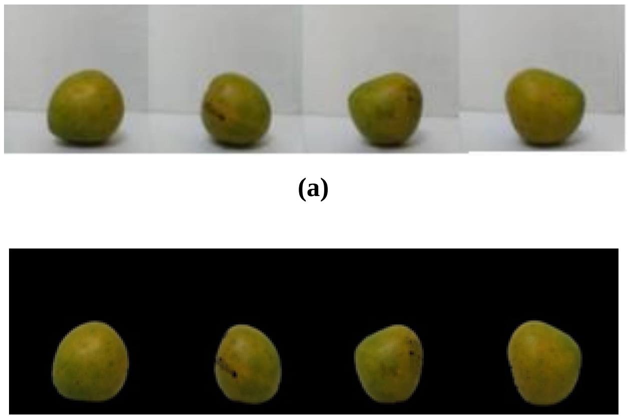


Fig.1 Flow diagram of the proposed methodology

A. Mango Preprocessing/Segmentation

Preprocessing is the first step in the proposed model which includes image resizing and image cropping. The next step is image segmentation which is used to separate the mango region from its background. Segmentation divides an image into its constituent parts or objects. The level to which this segmentation is carried depends on the problem being solved. In general, segmentation is most difficult part in image processing and it plays a very important role in further classification process. Mango in images are surrounded by different background and sometimes shadow. Vani Ashok et.al [10] have done comparison of k-means clustering and C-means algorithm segmentation technique with their histograms, obtained good result in k-means on apple images. we segment the mango images using modified K-means clustering segmentation technique where k=2.



(a)

(b)

Fig.2 Segmentation result (a)Before (b) After

B. Feature Extraction

During the ripening process of mango, the variation in the skin color and texture are seen to be more dominant in both artificial and natural ripened mangoes. In this section, the features which have been used to characterize the mango images are described. In this study, we have used color and texture features to represent ripened mangoes based on the ripening agent. Therefore, a number of features were initially chosen on the basis of observations for investigations. Totally, 29 features were selected; out of 29 features, 15 color features and 14 texture features. All the features were fused and normalized using min-max method. An introduction of color and texture features are shown in the below section.

C. Color Features

Color is the most dominating characteristic which can be identified during any fruit ripening process.
Ankur M Vyas et al [11] have reviewed various color feature extraction technique in detail. In order to measure the color existence in a mango region, we have extracted the mean and standard deviation of individual channels of four different color spaces such as RGB, HSV, CMY, CIE L*a*b from the segmented mango regions. Along with these color features, mean of RG, GB & BR are also extracted.
Let Pj be the jth pixel of a individual color space channel P of an image Y with M number of pixels in a color space. Then, the color moment is defined as follows:

Moments: Mean is the average value in the individual channel space which is given by

$$\mu = \frac{1}{M}\sum_{j=1}^{M} Pj \qquad (1)$$

Standard deviation measures the spread of the data.

$$\sigma = \sqrt{\frac{\sum (X - \overline{X})^2}{n}} \qquad (2)$$

The above described mean and standard deviation are calculated for every color space channel which results in 15 color features obtained by the following combination: (4 color spaces) x (3 channels in each color space)×(1 feature)+ 3 combination colors.

D. Texture Features

In order to evaluate the texture in a mango region, a set of statistical texture features based on the gray level co-occurrence matrix (GLCM) were considered. GLCM-based texture features are familiar and most extensively used methods for texture computation [12].
Haralick et al, (1973) proposed a set of scalar quantities to summarize the details in a GLCM[13]. These 14 features are Angular second moment, contrast, correlation, the sum of variance, inverse difference moment, sum average, sum variance, sum entropy, entropy, difference variance, difference entropy, information measures of correlation and maximal correlation coefficient. In order to obtain texture features, the normalized GLCM was calculated for each of the four orientations ({00, 450, 900,1350}) and a feature vector of 14 dimensions is created by taking the average of the features of individual orientation[6].

E. Classification

The problem of classifying chemically and naturally ripened mango is a big and complex task due to large intra-class variation. To performance this task, we have used k-nearest neighbor and support vector machine approach as a classifier here. The reason for these classifiers is that patterns are likely to belong to the same class when the features of the pattern are close to each other in the feature space. The neighbors are considered from a set of samples for which the correct classification is studied in k-NN [14] and Support vector machine (SVM) are supervised learning models with associated learning algorithms for data interpretation and pattern recognition, classification and regression analysis[15]. SVM is elected as good classifier for fruit grading. It gives more accuracy compared to the PNN[16]. In this work, K-NN with Euclidean distance measure and kernel function SVM are used to observe the effect on classification accuracy.

III. EXPERIMENTATION & RESULTS

A. Data samples

For the experimental works, we have created our own database since there were no existing database on mangoes, especially chemically and naturally treated. The dataset consists of 2 varieties of mango namely Badami(Alphonso) and Raspuri. Each variety consists of 2 classes which are naturally and artificially ripened. Naturally treated with paddy straw for a week. Artificially ripened mangoes were treated with 2 types of chemicals termed as Calcium carbide and Ethrel solution for ripening. So Badami variety consists of 1273 images and Raspuri consists of 1166 images. The work considered only two classes of mango to facilitate easier identification of the class of mango as the varieties cause more variable. Mango images are captured from five different resolution cameras like 5MP,8MP,12MP,14MP and 20MP resolution which covers all the views of the mango. The reason for chosen different resolution camera is, once the model is built, this model can be used further to develop android application so that the camera resolution will be feasible. The images have been taken with the three distances which are 12cm,14cm and 16cm between the camera and the object to make the distance is also quit feasible. To classify chemically and naturally ripened mangoes of each variety, only ripened mango images have been captured.

B. Performance Analysis

Further to evaluate the performance of the proposed model, extracted features are used to train the classifier and also to test the samples. In the literature [18], both parametric and non-parametric type of classifiers has been discussed. Experimentation has been conducted on databases of three classes in each variety with varying percentage of training samples. During the experiment, we have conducted an experiment of 100 trials for each set of training and testing samples randomly. In this study, we have used two classifiers namely, linear Support Vector Machine (SVM) and k-Nearest Neighbor (k-NN) classifiers.
For k-NN classifier, we have changed the k value experimentally and finally chosen suitable k value. The performance of the classification can be evaluated in the form of accuracy, precision, recall and F-measure from the confusion matrix of classification result. The performance can be calculated by using the equations described below with the following conventions.
TP (True Positive) =Positive samples classified as positive.
TN (True Negative) = Negative samples classified as negative. FP (False Positive) = Negative samples classified as positive. FN (False Negative) = Positive samples classified as negative.
Precision: It is the ratio of number of positive samples correctly classified to the total number of samples in a class.

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

Recall: It is the ratio of number of positive samples correctly classified to the total number of samples classified as positive.

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

F-measure: It is the harmonic mean of precision and recall given by the equation below.

$$\text{F-measure} = \frac{(2*\text{Precision}*\text{Recall})}{\text{Precision} + \text{Recall}}$$

Accuracy: It is the ratio of a total number of samples truly classified to the total number of samples taken as given by the equation below.

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

The performance measures of the classifiers is calculated for 100 trails is presented. The F-measure results are tabulated in Table 1, Table 2, Table 3 and Table 4 respectively with varying percentage of training. Average accuracy for 100 trials with varies percentage of Training are shown in Fig.3, Fig.4. According to the result, we have obtained a better accuracy using SVM classification technique. Based on the performance of the proposed model we have observed the performance of the system is quite less remarkably because more of intra class variations and less inter class variations.

Table I. Average F-measure with two classifiers for Natural and Calcium Carbide treated mangoes of variety Badami

Percentage of Training Samples	k-NN	SVM
30	0.5877	0.6421
40	0.6118	0.6506

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50	0.6128	0.6589
60	0.6261	0.6672
70	0.6351	0.6753

Table II. Average F-measure with various classifiers for Natural and Ethrel treated mangoes of variety Badami

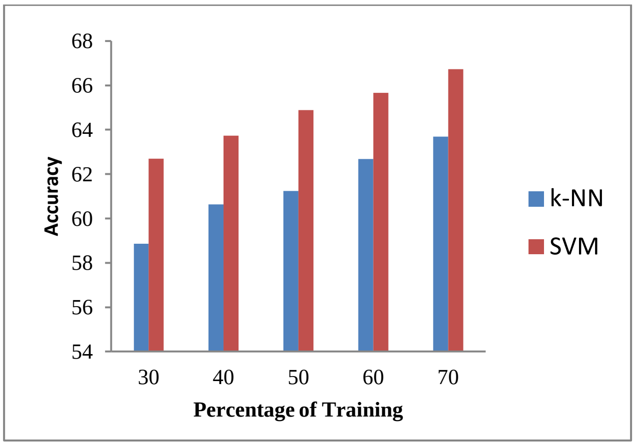
Percentage of Training Samples	k-NN	SVM
30	0.7188	0.8245
40	0.7338	0.8289
50	0.7481	0.8335
60	0.7510	0.8351
70	0.7565	0.8362

Table III. Average F-measure with various classifiers for Natural and Calcium Carbide treated mangoes of variety Raspuri

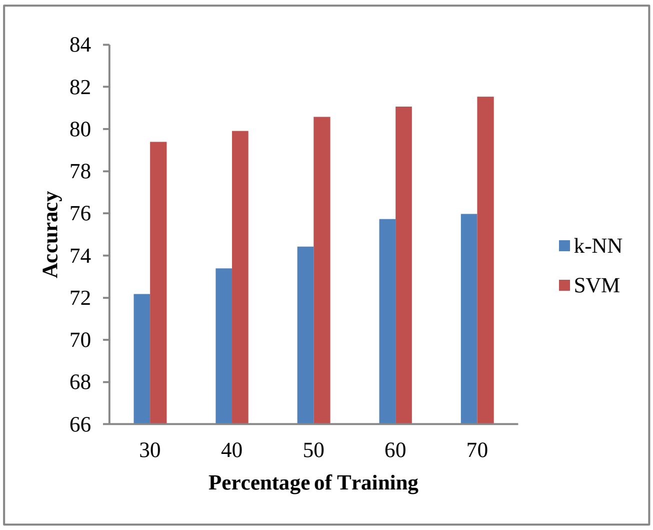
Percentage of Training Samples	k-NN	SVM
30	0.715	0.7210
40	0.724	0.7260
50	0.730	0.7291
60	0.7343	0.7295
70	0.7359	0.7887

Table IV. Average F-measure with various classifiers for Natural and Ethrel treated mangoes of variety Raspuri

Percentage of Training Samples	k-NN	SVM
30	0.7854	0.8262
40	0.7948	0.8366
50	0.8010	0.8419
60	0.8100	0.8444
70	0.8120	0.8480

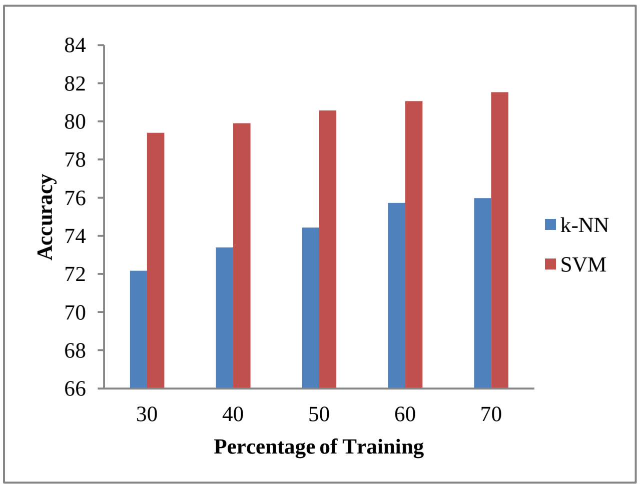


(a)

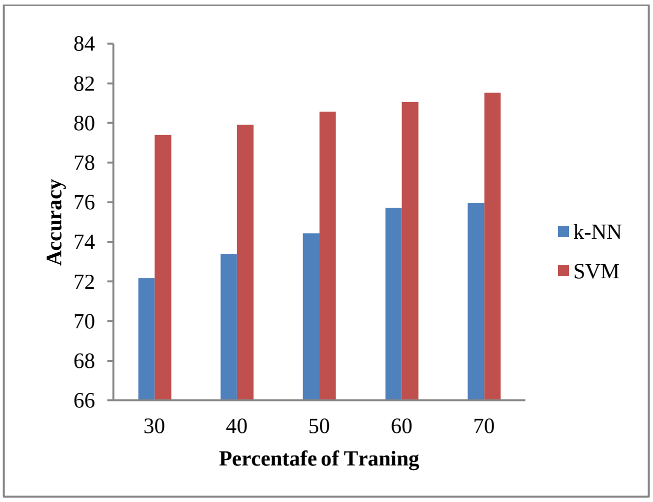


(b)

Fig.3 . Classification accuracy for different classifiers for Badami (Alphonso) (a) Natural and Calcium carbide treated mangoes (b) Natural and Ethrel treated mangoes.



(a)



(b)

Fig.4 . Classification accuracy for different classifiers for Raspuri (a) Natural and Calcium carbide treated mangoes (b) Natural and Ethrel treated mangoes.

IV. CONCLUSION

In this proposed work, two varieties of mango were chosen such as Badami (Alphonso) and Raspuri. In each variety of mangoes, three classes have been considered namely mangoes treated with naturally, calcium carbide and ethrel solution. Experiments were conducted on our own dataset of 1273 images in Badami and 1166 images in Raspuri of with 3 different classes of mango in each variety. From these three classes of mangoes, 29 features were extracted which includes fusion of color and texture features.

Then the classification is performed with SVM and k-NN Classifiers. We have observed that accuracy and F-measure are increased as the number of training samples are increased with both k-NN and SVM classifier The computed accuracy and F-measure of the classification shows that the SVM classifier is outperforming [19]. The performance also found to be reasonable good in comparison with human experts.

We have noticed that the accuracy or F-measure of the system is quite considerably less. This is due to a less interclass variation and more intra class variation. The strength of this model is, it works for any resolution images between 8MP to 20MP and also from the distance 12cm to 16cm. Further this model can be used to develop as an android application at the market for consumers.

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