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Grapes Ripeness Estimation using Convolutional Neural network and Support Vector Machine

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***Abstract*— India is worldwide well known for exporting fruits, having a massive significance in the world. Global food security is essential for the durable production of fruits as well as for a remarkable reduction in pre and post-harvest waste. Harvesting and estimating the ripeness of fruits by a human is an expensive, laborious and time-consuming task. Ripeness estimation is carried out on single fruit like orange, apple, tomato, banana, papaya and etc., using color features. By taking into account increasing productivity of grapes and there is need to focus on ripeness estimation of grapes at the correct time. In this paper, we proposed a methodology that classifies grapes image into ripen and unripen category. A local breed of grape 'Sonaka' was examined during the harvest season from January to March 2019. The images were separated into two ripen categories, e.g. unripen and ripen according to the color and shape of grapes. This image was subjected to a classification model like Convolutional Neural Network (CNN) and support vector machine (SVM). Color features such as RGB and HSV and morphological features such as the shape of grapes were chosen as features for this classification model. The validation result shows that the CNN model achieves higher classification accuracy with 79.49% than the SVM classifier having 69%.**

Keywords*— *Grapes ripeness estimation, Image pre-processing, Deep Learning, Convolutional Neural Network(CNN), Support Vector Machine(SVM)

I. INTRODUCTION

Agriculture plays a main role in wealth and is the major source for the nation's administrative income. India is renowned for exporting fruits. The essential factor in charge of good showcasing of fruit is its quality. For some fruits, the primary measure of quality is its maturity. Identifying ripeness of fruits by a human is a dreary, costly, arduous and time-consuming task. Consequently, automatic prediction of fruit maturity is required. Quality of fruit depends on aspects of fruit image which are color of fruit and morphologic highlights such as size of fruit. Color has is basically utilized the feature to distinguish ripeness for different fruits like tomatoes, watermelons, bananas, grapes, apples and dates. The visible aspect of the fruit is used to decide its ripeness, which is decided by color, size, texture and shape. Out of these factors, color is the most major factor. It has a high effect on the quality of fruit.

Estimation of fruit maturity plays main role to expand the revenue of the agriculture business. The utilization of deep learning and machine learning with image processing for the review of fruits has grown significantly in past years but all research has been done for single fruit such as banana, mango, papaya and etc. The studies till now have been worked on only color features, for example, RGB and HSV values and some of the researchers considered only morphological properties like size and shape. Using multiple features like color and physical together has not been focused widely. Coordinating two or more features together can improve accuracy. There is a huge call for wine factories that's why for grapes also. Grapes screwed early so there is a need to accurately estimate ripeness stage of grapes at the correct time. Till now not so great research has been performed in maturity estimation for grapes. Lots of researchers utilized machine learning algorithms for the maturity classification of fruit. So there is the scope of working on deep learning with image processing [1].

In the present research, we used Convolutional Neural Network and support vector machine for classification grapes image into ripen or unripen category. CNN works better on images and huge data plus neural network has the proficiency, to detect complex and highly non-linear relationships, such as are likely to categorize grapes image. We used 4000 grapes images as dataset with color features, RGB and HSV values and morphological feature as shape of grapes. The objective of this study analyse the accuracy of deep learning algorithm such as CNN with machine learning algorithm such as SVM to classify image whether it is ripen or unripen.

The paper is organized into following sections. Section I presents the introductory for estimation of grapes ripeness. Section II presents the related work, III section includes proposed methodology for grapes ripeness estimation using CNN and SVM. Section IV presents the in depth implementation details of system and section V conclude the paper.

II. RELATED WORK

Different approaches have been proposed to appraise ripeness of fruits. In recent couple of decades enormous work is done in the study of estimation of maturity of fruits. Numerous researchers have considered the problem of ripeness estimation of different fruits. [2] Presented an overview of various techniques for example, pre-processing, extracting features, classification, and investigation which tended quality of fruits dependent on color, size, shape and size of fruit. Additionally completed a comparison of algorithms for checking quality of fruits. [3] Developed classification approach to detect ripeness of apple dependant on color using Artificial Neural Network. 600 pictures of apple utilised as dataset in this research. Color features

utilized in this research are mean, chromaticity, variance, standard deviation and skewness of RGB color. This study gave 96.66% of precision. [4] Introduced a multi-class characterization approach for exploring and classifying phases of maturity of a tomato. PCA algorithm is utilized for extracting features, to produce a vector of features for every picture in the dataset. The proposed methodology uses color features and SVM algorithm is used for classification. As a dataset, 250 pictures of tomato that have been utilized and 90.2% accuracy have been accomplished with this dataset.

Machine vision-based framework [5] presented for classification of mangoes by foreseeing maturity level likewise intended to replace a manual classifying framework. The CCD camera set on the highest point of transport belt, collected the video signals for classification of maturity level. The SVM classifier is used to detect the most pertinent features among the first picked 27 features from extracted picture frames from the video. [6] Used development strategies from image processing and machine learning algorithms for Programmed classification and calculating the count of fruits. This technique automatically distinguished and classified ripeness level of apple fruit, regardless of whether it is mature or immature dependent on its color features. In this study, a total of 104 images is gathered online, comprising 52 of immature and 52 of mature. With Back Propagation Feed Forward Neural Network, 98.1 % accuracy has been accomplished for classification. [7] Presented how machine learning algorithms and computer vision can be consolidated current vineyard executives with vinification procedure to accomplish industry applicable outcomes. GrapeCS-ML Database comprises pictures of grape breeds at different stages of improvement together with the comparing ground truth information (for example pH, Brix, etc.) got from concoction investigation. The target of this research is to persuade machine learning and computer vision to develop practical answers for development in smart vineyards. [8] Estimated ripeness of grapes using seed images. Neural network is utilized to separate grape images into mature, immature and over-mature. In this research, 277 seed pictures are captured using scanner as a dataset and RGB values consider as features. This study accomplish the 90% accuracy using neural network. [9] Aims to recognize ripeness levels of grapes by utilizing visible and near infrared spectrophotometer as indicated by the sugar content. A total 230 grapes images were gathered a grape cultivar 'Beyond' in Shaoxin, China during harvest time from July to August, 2011. In this investigation LDA, BPANN and SVM approaches are utilized. For computerization harvesting [10] points in discovering the maturity of grapes bunches. It was a two-way procedure, where the grape bunches are segregated from the background of an image utilizing image processing and computational insight technique in the first phase and in the second phase the grape bundle is classified into mature and immature group using SVM. This study accomplishes 96.88% accuracy on a dataset of 31 images on grape vineyards in Cambridge. [11] Introduced an easy and successful way to classify smaller datasets of hyperspectral images of fruits with standard, enormous convolutional neural networks optimized for RGB image data. 2700 images were considered for this study. The results demonstrated that the hyperspectral image data expands the average classification accuracy from 88.15% to 92.23%. [12] Proposed system found out the artificially ripen fruit using an image of fruit by comparing it's features with naturally ripened fruit. This strategy makes utilization of cell phone which runs the android application and the convolutional neural network to identify the misleadingly matured natural fruit. 1000 images of fruits belonging to each class at various phases of ripeness were considered for this study.

III. PROPOSED METHODOLOGY

The proposed framework of the estimation of ripeness of grapes fruit is shown in Fig.1 below,

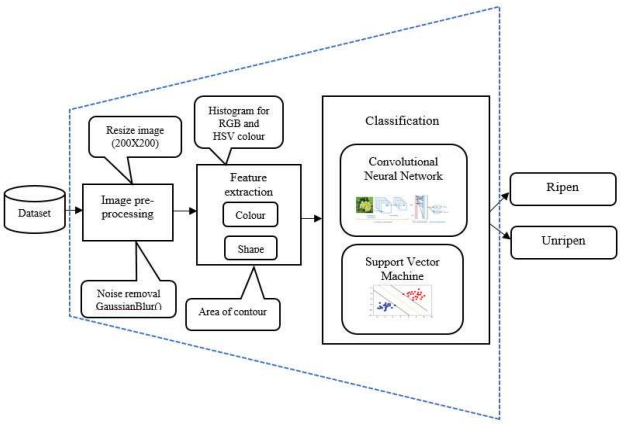

Fig. 1 Architecture diagram

We have implemented the system into four phases: Data collection, image pre-processing, feature engineering and classification. All modules are composed in python programming language, for experimentation purpose we have used 4000 images of grapes fruit considered as a dataset. According to above figure, dataset is submitted to pre-processing, which principally involves noise removal, resizing. This pre-processed data is further moved to feature extraction. Color features such as RGB and HSV values with shape of grapes is extracted. After performing feature extraction, extracted data is then passed as input to the classifier classifier and result is obtained. That grapes image is ripen or not.

A. Image Collection

For the study of ripeness estimation of grapes ripeness, standard and large datasets are not much available in the public domain. This has inspired us to develop our own dataset for the purpose of research. Grapes images were captured from a local grape breed 'Sonaka' in Nashik, Maharashtra, India during harvest time from January to March 2019 using smartphone one plus 3T. The samples with the highest RGB and HSV value and area of shape considered as ripen grapes. A collection of total 4000 images including 2000 unripen and 2000 ripen grape images captured at the above harvest time were considered for this study. Fig.2 shows few samples out of a dataset of 4000 images.

Fig. 2 Sample images from dataset

B. *Image pre-processing*

An image consists of various noises which worsen the features of an image. Therefore, it cannot give relevant data for image processing. For that purpose, in this project image noise got removes using GaussianBlur() function and resized the image into 200X200 dimension.

C. *Feature Extraction*

Features like color is used to describe the characteristics of images. So we have extracted color features such as RGB and HSV using histograms. For morphological feature such as shape of grapes calculated using area of contour. OpenCV library in python is utilized to extract the above features using inbuilt functions and various formulae.

D. *Convolutional Neural Network*

Convolutional neural network is a deep learning algorithm which worked best for images. So, after pre-processing is done, then CNN is used to classify images into 2 categories. Convolution neural network is written using keras and with TensorFlow as a backend. The dataset has been loaded with First 2000 images as ripen category and last 2000 images as unripen category loaded a dataset for training purpose to CNN. 25 % of images from total dataset chosen randomly as a validation set and remaining is for training set. To classify the grapes image, the model's input layer accepts the image as an input then changed the image into the 2-dimensional array of variables and offers it to the following layer i.e. hidden layer. Based on what the node is, it will perform its function. After that output layer which reveals the class to which the input image belongs to. For convolution process convolutional layer uses the kernel of size 2x2 along with 16 filters with activation function Rectified Linear Unit and optimizers such as RMSProp and Adam.

E. *Support vector Machine*

SVM is a supervised non-parametric statistical learning technique that is generally used for classification by building a hyperplane in a high-dimensional space. Hyperplane segregates data into two classes, here the classes are ripen and un-ripen. In this study, we used the svc function to fit models and the predict function to anticipate class labels. The above function was implemented using the sklearn library.

IV. Performance Analysis

Performance of analysis of classifiers such as CNN and SVM for classification of grapes image into ripen and unripen category performed on grapes dataset. Dataset contains 4000 images, including 2000 ripen and 2000 unripen images. We have divided dataset into 2 parts one for training which includes 2808 images and 1204 images for validation set. The results are shown for accuracy for CNN and SVM classifier, optimizers of CNN model such as RMSProp and Adam, different layers and dataset size.

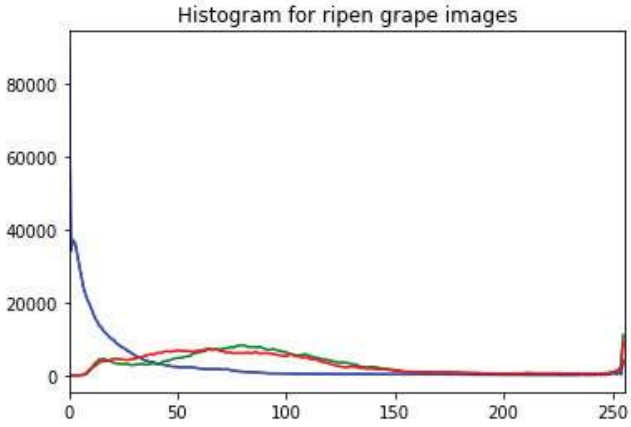

Fig. 3 Histogram for ripen grape image

Analysis of graph: Figure 3 shows derivation of threshold for unripen image of grapes using color histogram method.

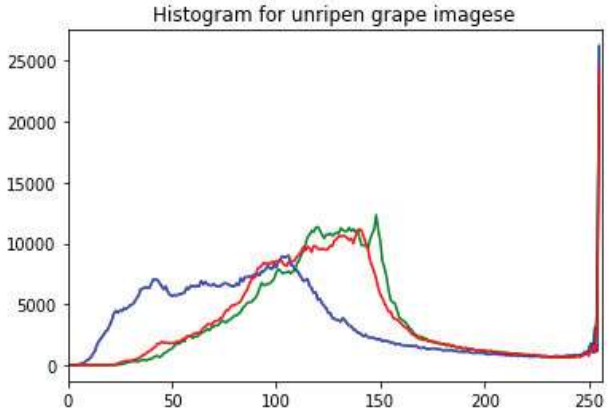

Fig. 4 Histogram for unripen grape image

Analysis of graph: above figure shows derivation of threshold for ripen image of grapes using color histogram method.

Fig. 5 Edge detection of grapes image

Analysis of graphs: For derivation of threshold for ripen and unripen grapes, firstly we performed edge detection on the basis of contourArea() function.

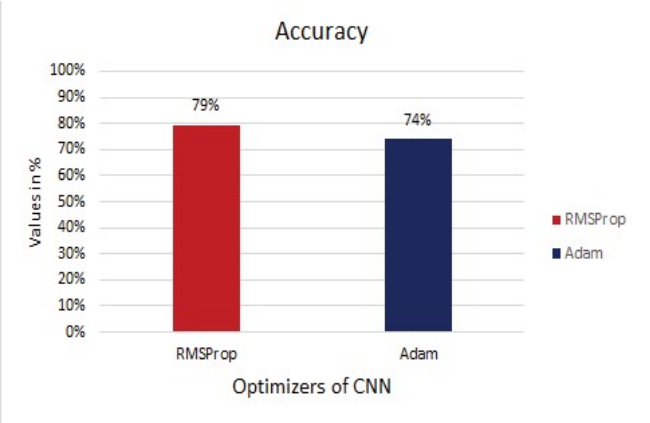

Fig. 6 Comparative graph for RMSprop and Adam optimizer in CNN

Analysis of graph : From above graph we can analyse that the RMSProp optimizer gives best validation accuracy with 79.47% than Adam optimizer with 74% in CNN.

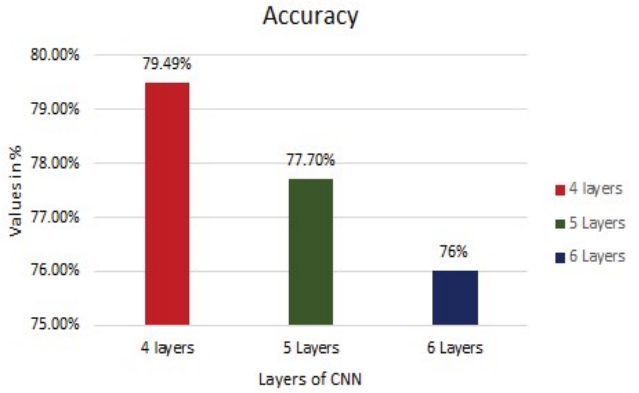

Fig. 7 Comparative graph for 4, 5 and 6 CNN layers

Analysis of graph: From above graph we can analyse that with 4 layers gives best validation accuracy with 79.49% as compared to five and six layer in CNN.

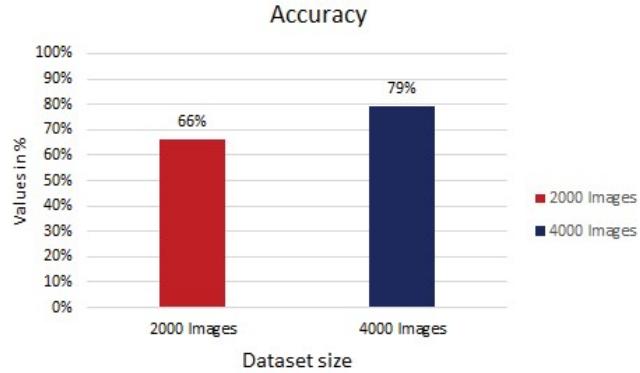

Fig. 8 Comparative graph for dataset size with CNN

Analysis of graph: From above graph we can analyse that the validation accuracy for CNN is best with huge amount of images i.e. 4000 images as compared to 2000 images.

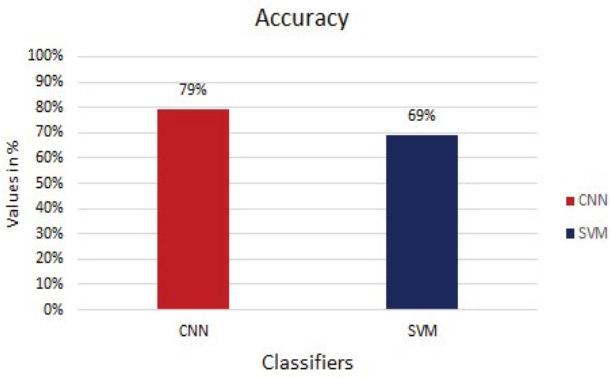

Fig. 9 Comparative analysis of validation accuracy for CNN and SVM

Analysis of graph: In terms of accuracy CNN has the max accuracy of 79% than SVM, as CNN works better for image dataset.

The comparative analysis for Precision , F1 score and Recall shown in Table 1 for CNN and SVM classifier. It is evident that the CNN classifier is more precise, has more recall ability and more f1 score than SVM.

TABLE I. PRECISION, RECALL AND F1 SCORE

Figures of merits	CNN	SVM
Precision	80%	70%
Recall	83%	70%
F1 score	80%	69%

In fig. 10, graphs are plotted using the above Table 1, from which it can be concluded that CNN gives best f1 score precision and recall.

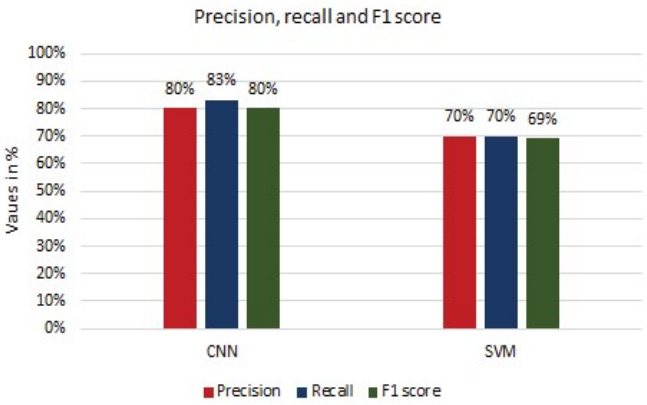

Fig. 10 Comparative graph for precision, F1 score and recall for CNN and SVM

By inspecting the results in above figures, we can infer that the CNN classifier provides the most optimal results for classification of ripeness stages of grapes fruit.

V. CONCLUSION

In this work we have used deep learning technique such as convolutional neural network and machine learning algorithm like support vector machine to recognize ripeness of grapes fruit from image. Image processing is carried to process grapes image and extract the required features as RGB and HSV values with the shape of grapes. We got result such as comparison between the accuracy of SVM

and CNN model and comparative analysis between optimizers of CNN mode, comparative analysis between 4,5 and 6 layers of CNN layers. The Convolutional Neural Network (CNN) classifier model achieves the highest accuracy of 79% while the accuracy of the SVM model is 69%. With optimizers, RMSProp gives better accuracy with 79% than Adam optimizer having 74% plus CNN model achieved more accuracy with huge dataset has been proven by training CNN model on 2000 image dataset and 4000 image dataset. As, 79% accuracy is achieved with 4000 image dataset while 66% accuracy is achieved after model training on 2000 image dataset. We have used TensoFlow framework for implementing CNN, the network consists of 2 convolutional layers, 1 fully connected layers and 1 dropout layer and with 20 epochs. The developed system speeds up the process of estimation of grapes ripeness with high accuracy and using large dataset. We achieved highest 79% accuracy on the images obtained from a local breed 'sonaka' of vineyard in Nashik, Maharashtra, India.

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