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Automated estimation of grape ripeness

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Abstract— **India is worldwide well known for exporting fruits, having immense importance in the world. Global food security is necessary for not only durable production of fruits but also for remarkable reduction in pre and post- harvest waste. Harvesting fruits and detecting ripeness of fruits by human is an expensive, laborious and time consuming task. For this reason, there is need for an automated ripeness estimation system in the last decade. Fruit ripeness estimation is major task that influence its quality and later its marketing. Researchers have started targeting towards for the study of ripeness estimation using methods in image processing and machine learning to automatic classification of ripeness of fruit accurately, quickly and non-destructively. Traditional methods for fruit ripeness estimation considered fruits such as orange, apple, tomato, banana, papaya and etc. which is single fruit. By taking into account increasing productivity of grapes and bunch of berries in grapes need to focus on estimation of ripeness of grapes fruit. We have reviewed various studies in this domain and believe this is a primary effort in summarizing the highlights of researches done. This will give direction for fellow researchers.**

Keywords— *Ripeness estimation, image processing, Deep Learning, Convolution Neural Networks*

I. INTRODUCTION

Agriculture plays a crucial role in the wealth and is the major source for country's governmental income. India is famous for exporting fruits. Basic factor responsible for compatible marketing of fruit is its quality. For many fruits the main measure of quality is its ripeness. Distinguishing ripeness of fruits by human is a monotonous, costly, laborious and time consuming task. For this reason automatic prediction of fruit ripeness is required.

Quality of fruit is based on aspects of fruit image which are color of fruit morphologic features such as shape, size and texture attributes. Color is primarily used feature to distinguish ripeness for various fruits, vegetables like tomatoes, watermelons, bananas, grapes, apples and dates. The visible aspect of the fruit is used to decide its ripeness, which is decided by colour, size, texture and shape. Out of these factors, color is the most major factor. It has high impact on the quality of fruit. Automatic estimation of fruit ripeness plays vital role to increase the revenue of agriculture industry. The use of machine learning and deep learning with image processing for the inspection of fruits has grown considerably in past years. Computer vision technique can be used for capturing and analyzing an image of a real data and then classifying ripeness of fruit into three stages such as ripe, overripe and unripe.

II. LITERATURE SURVEY

Over the past few decades huge work is done in the study and analysis of estimation of ripeness of fruits. Many researchers have considered the issue of ripeness estimation of different fruits.

[1] Presented a detailed overview of various methods i.e. pre-processing, feature extraction, classification and analysis which addressed quality of fruits based on colour, size, shape and size. Also done a comparison of algorithms for checking quality of fruits.

For automation harvesting [2] aims in finding maturity of grapes bunches. It was a two way process, where the grape bunches are separated from the background of an image using image processing and computational intelligence method in first step and in the second step the grape bunch is classified into mature and immature group using support vector machine algorithm. The result of this study gave 96.88% accuracy on a set of 31 images on a patch of grape vineyards in Cambridge, Tasmania with resolution 2248X3264.

[3] Proposed a system that categorized maturity of persimmons fruit into ripe, overripe and unripe categories. In these study, 88 images of persimmons fruits are captured and features mean of RGB value, nutritional properties of permission fruit such as titratable acidity, pH value and total soluble solid. For these study QDA classifier is used. It gives high accuracy of 90.24%.

[4] Investigated classification approach to estimate ripeness of apple based on colour using Artificial Neural Network. 600 images of apple used as dataset in this study. Colour features used in this study are mean, variance, chromaticity, skewness and standard deviation of RGB colour. These study gave 96.66% of accuracy.

[5] Presented a multi-class classification approach investigating and classifying stages of ripeness of tomato. PCA algorithm is used for feature extraction technique to create a feature vector for each image in the dataset. The proposed method used colour features for feature extraction and for classification of tomato ripeness stages SVM method is used. Support vector machine and LDA algorithm is used for classification of ripeness stages. Total 250 images that has been used as a dataset and accuracy of 90.2% has been achieved with this dataset.

[6] Predicted quality of indices of bananas using colour parameters of support vector regression (SVR). For estimation of quality indices, component concentrations, chemical and physical properties from colour features of banana during shelf-life, radial basis function is used. In this study, from sample bananas high quality images were taken by a Power shot colour camera at a vertical distance of 25 cm above the sample. Quality of indices of bananas predicted with 91.65% accuracy.

[7] Estimated the ripeness of tomato using Fuzzy Rule-Based Classification method based on colour space. Dataset for this study constructed by capturing the real images that were taken from a farm. In first phase of this study identified tomatoes and in the second phase classified them into different ripeness categories. Colour features and colour categorization this are two sub-processes were comprised for classification.

Machine vision-based system [8] proposed for classification of mango fruit by classifying maturity level. The Charge Coupled Device camera is used for collecting the video signals for prediction of maturity level of mango. Recursive feature elimination method is used in this study with support vector machine (SVM) classifier to find the most relevant features from the originally chosen 27 features from image which is extracted video signal.

[9] Used advance techniques from image processing and machine learning algorithms for automatic classification and counting of fruits. This method automatically detected and classified maturity level of apple fruit, whether it is mature or immature based on its colour features. In this study, total 104 images are collected online using images.google.com consisting 52 of mature and 52 of immature. This study used Back Propagation Feed Forward Neural Network (BPFFNN) for classification which gives highest accuracy as 98.1 %.

[10] Aims to classify maturity level of mango correctly. Proposed system generated Membership function automatically and used Fuzzy rule that considers both the accuracy of model and easy interpretability. Total 108 images are collected in controlled environment using digital camera as dataset and features like size and shape. Using fuzzy learning technique for deriving MFs and fuzzy If-Then rule, analysis results shown that proposed classifier gives an accuracy of 98%.

[11] Purpose of this study is to detect the ripeness of banana and classify into three categories such as ripe, unripe and overripe. 60 bananas images are captured by using Microsoft NX6000 camera as dataset and histogram of RGB value components considered as features. For classification of ripeness levels of fruit bananas ANN algorithm is used.

[12] Classified ripeness phases of banana into ripe, unripe, and overripe using fuzzy model.
MUSA dataset is used and features like peak hue and normalized brown area (NBA), HSI and of CIELa*b* are captured from image. Approaches used in this study are Regression Tree (CART) and classification algorithm and banana ripening decision were made by a framework of 8 fuzzy rules that are obtained from decision tree. Result of this study demonstrate average classification rate of 93.11%.

[13] Presented an image classification method to categories the ripeness stages of tomato fruit. 175 images for training and for testing 55 images were collected as datasets from an estate in Minia city as a dataset and colour features such as HSV histogram and colour moments are obtained. Principal components analysis method is used for extracting features and

SVM algorithm is used for classification of ripeness of fruit. Using SVM algorithm 92.72% accuracy is achieved.

[14] Aims to classify the Cape gooseberry fruit into different ripeness level. Machine learning algorithm such as artificial neural networks, support vector machines, decision trees, and K-nearest neighbors were used on 926 Cape gooseberry fruit images with resolution 1280x720 pixels. From RGB space, median colour parameter values are extracted and transformed into the HSV and L*a*b* colour spaces as features. In this study, the mean accuracy obtained for RGB as 72.29%, for HSV 57.76% and for L*a*b* 75.99%.

Idea of [15] is to parallel analysis of two broad-spectral images of banana fruit, which is taken under ultraviolet illuminations and white light. The smart phone with 2592×1952-pixel digital camera is used for capturing the images of 10 types of banana. A two-level image thresholding algorithm and features such as RGB colour ratio are used for classification of banana fruit into unripe, ripe and overripe stages.

Using recognition patterns such as texture and colour analysis from image [16] classified the tomato fruit into different maturity levels. This study used Grey Level Co-occurrence Matrix (GLCM) method with dataset of 100 images of tomato. Dataset includes 75 training data and 25 testing data that yields accuracy rate of 100% with membership value (k) in K-NN is 3 p and value (distance) n GLCM is 9

[17] Classified ripeness levels of strawberry fruit using hyperspectral images with spectral ranges (380-1030 nm and 874-1734 nm). Principal Component Analysis (PCA) method is applied on spectral data which is extracted from images of ripe and unripe strawberries. 60 ripe strawberries, 60 mid-ripe strawberries and 60 unripe strawberries were captured from a local strawberry estate in Hangzhou, china using a 672×512 CCD camera with features such as texture features and optimal wavelengths. SVM model showed best result on combining datasets of texture features and optimal wavelengths.

[18] Studied computer vision and machine learning algorithms for combining with current vineyard management and vinification processes to reach industry relevant outcomes. GrapeCS-ML database is established which composed varieties of grapes images at different stages of development with corresponding features like pH and Brix. Objective of this study is to motivate computer vision and machine learning researchers to develop practical solutions for deployment in smart vineyards.

[19] Estimated maturity of grapes by analyzing seed images. Neural network algorithm is used to classify grapes into immature, mature and over mature states. In this study scanner is used to capture 277 seed images as a dataset and features such as RGB value and histogram of colour space. This study gives the 90% accuracy using neural network classifier.

Backpropagation Neural Network method used in [20] to classify ripeness levels of tomato into red, green and orange. 150 images of tomato are captured using camera (SONY NEX- 5N, Tokyo, Japan) with lens zoom of between 18 and 55mm as a dataset and colour features such as RGB and HSI models are considered. This study gives 99.31% accuracy for detecting three maturity levels of tomato.

[21] Developed a colour grade chart and classified ripening stages of mango using the Physicochemical properties such as brix, pH, acidity, TSS and textural and colour measurement such as (Li*,ai*,bi*). Banganapalli and Alphonso this two species of mango were collected from Theni and Krishnagiri Tamil Nadu, at 20 days interval.

[22] Aims to identify unripen, over ripen and ripen grapes using visible and near infrared spectrophotometer based on the sugar content in grapes. Total 230 grapes samples were collected a local grape cultivar in Shaoxin, China during harvest time from July to August, 2011. USB4000 with spectral range of 345-1048nm at 0.16nm is used to scan spectra data of samples. Linear discrimination analysis (LDA), back-propagation artificial neural network (BPANN) and support vector machine (SVM) approaches are used for classification.

Main focus of [23] was to decide the quality of banana using dielectric spectroscopy and image processing techniques. In this study 100 samples of bananas are classified into unripe, ripe and overripe categories using impedance spectroscopy. Sugar soluble content is used as a feature and fuzzy logic method is used for classification.

Using natural outdoor images in [24] identified ripeness stages as mature, mid-mature and immature of blueberry fruit. Total of 46 images were captured from a commercial blueberry farm in Waldo, USA using a digital DSLR camera with 3648X2736 pixels resolution as a dataset and forward feature selection algorithm is used for selecting features such as hue,

red and blue. SK-means classifier is used for segregating mature and mid-mature fruit with accuracy 90%.

[25] Presented a hyperspectral-based system to estimate the ripeness of oil palm fresh fruit bunches. Total 469 oil palm fresh fruit bunches scanned using hyperspectral device and reflectance was recorded at different wavelengths. Artificial neural network method is used for classification of fruit into ripe, unripe and overripe stages with 95% accuracy.

Sr	Title of paper	Algorithm	Dataset	Features	Results
1	Computer Vision and Machine Learning for Viticulture Technology	SVM, KNN, decision tree, boosted tree, SAE	GrapeCS-ML Database	pH, brix	SVM classifier gives highest performance among the classifiers followed by SAE and k-NN.
2	Grape maturity estimation based on seed images and neural networks	SFS and neural network	Using scanner captured 277 seed images	RGB value and histogram of colour space	This study gives the 90% accuracy using neural network
3	Apple Ripeness Estimation using Artificial Neural Network	ANN	600 of apple taken from the website http://www.fruitid.com	Mean, variance, chromaticity, standard deviation and the skewness of the RGB image	Estimated the ripeness of apple fruits based on colour with accuracy 96.66%
4	Identification of Mature Grape Bunches using Image Processing and computational Intelligence Methods	SVM	31 images of grapes taken with resolution 2248X3264	Colour feature such as RGB and HSV values	The result of this study gave 96.88% accuracy
5	A Fuzzy Learning Algorithm for Harumanis's Maturity Classification	Fuzzy rules	Total 108 images are taken using digital camera	Size and shape	Classifier yields an accuracy of 98%

Table I. Summary of literature survey

Thus as given in Table I equivalent work in the area of ripeness estimation of fruit involve considering images of fruits and approaches used include machine learning algorithms, deep learning methods and fuzzy rules with colour features and attributes like shape, texture and size. Fruit images have been taken as a base for task of estimation of ripeness.

A. Research Gaps.

1) All the researches done till now are worked on only colour features such as RGB and HSV values and some of researchers considered only physical properties such as size and shape. Using multiple features like colour and physical together has not been focused extensively. Integrating two or more technique together can improve accuracy.
2) Lots of researchers used machine learning algorithm for ripeness estimation of fruit. So there is scope of working in the field of deep learning with image processing.
3) There is a huge demand for wine factories that's why for grapes also. Till now not so great research has been done in ripeness estimation for grapes.

III. PROPOSED ARCHITECHTURE

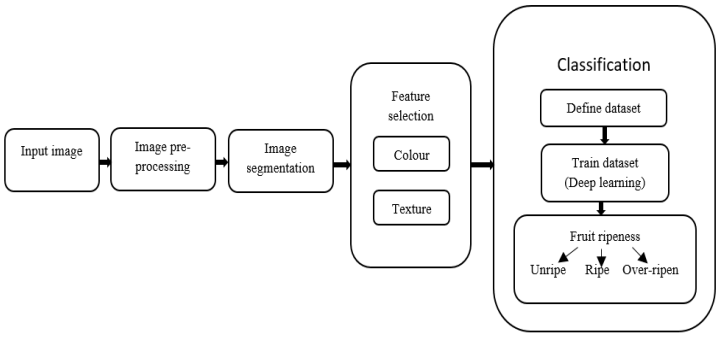

Figure 1. Proposed System Architecture

System architecture for our proposed study is given in Figure 1. According to it, proposed system having five phases. In image collection step images of fruits are captured. From these collected images relevant information for ripeness estimation is gathered and it is used to construct the dataset. Generated dataset is further submitted to pre-processing.

Images captured by various types of methods. Image contains of many noises which worsen the quality of an image. Therefore, it cannot give appropriate data for image pre-processing. The image pre-processing method magnify the image data, which overcome disinclined distortions and expand the features of image that are essential for processing and build a pertinent image than the original for a definite application. Local pre-processing and pixel pre-processing these two methods used for quality assessment of fruits in image pre-processing.

After image pre-processing, image segmentation is required which segregates a digital image into distinct areas. The major function is to discrete the background for processing the significant area while fruit evaluation. A genuine segmentation is decisive for further processes in image analysis and an improper segmentation will reduce the classifiers performance. Approaches used for segmentation are k-means clustering, thresholding and fuzzy c-means.

After image segmentation, extracted features for further analysis. These features consist of important data for image clarification and fruit classification. For analyzing the ripeness of fruit colour, textural and morphological features are widely used.

The essential step for ripeness evaluation of grapes fruit is classification which granted a structure in which artificial assumption of human thinking is done to lead humans from experienced judgments instantaneously, correctly and persistent. By using image processing methods, fruits images can be reported by set of features such as colour, size, shape and texture. Above features are used to form training set, then Convolutional Neural Network algorithm for classification (deep learning algorithm) is used to pull out knowledge base which make a decision such as grapes is ripen or not.

Application:

• Agricultural: Harvesting fruits and detecting ripeness level of fruits by human is a tedious, expensive, laborious and high time consuming task. For this reason there is great scope automatic estimation of grapes fruit ripeness.
• Industrial: Today wine factories have a huge demand. So, accurate detection of grapes is needed. Grapes screwed early so this system will accurately estimate ripeness stage they are likely to be screwed

IV. CONCLUSION

Fruit ripeness estimation is a promising and exiting area for research and has attained great importance. Ripeness estimation happened till now have considered colour features, textural features and morphological features with different machine learning algorithm such as KNN, SVM, ANN, K-Means, Fuzzy rules and etc. Some of the researches have used deep learning algorithms. It is found that among the different methods, Deep Learning with fusion of colour features and textural features together has the highest accuracy. Hence future scope is to consider deep learning algorithm with combining more features together for classification to achieve more accuracy.

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