# NON-DESTRUCTIVE CLASSIFICATION OF FRUITS BASED ON COLOR BY USING MACHINE LEARNING TECHNIQUES

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#### Abstract

Inclusion of computer vision and image processing technique in agriculture field providing a user friendly environment in quality testing and grading of fruit before placing it in market. Automated quality testing and grading of fruits influenced with the extracted quality parameters of fruit image and number of dataset used in training phase of machine. Color, size, texture and surface defect are the basic parameters in quality measure of fruits in agriculture field. This paper focused on classification accuracy based on extracted color and geometric features of fruit mango (magniferia Indica) and used sample size in training phase of machine learning algorithm. In this study maturity of mango is predicted with extracted color features by using a combination of RGB, HSI, HSV color model and classification is done using Naïvebayes and BPNN machine learning algorithms. This complete method passes from three phases 1) image pre-processing 2) feature extraction and 3) classification. The experimental results illustrate the usefulness of these measures by providing the

prior information in classification. BPNN results are satisfactory in both cases of used features like i) color features ii) color and geometric features.

#### Index Terms: Classification, Machine Learning, BPNN, Naïv bayes, computer vision.

#### **1.INTRODUCTION**

Mango (Mangifera indica L.) called king of fruits in India is one of the most important fruits of the world, found mostly in tropical and subtropical regions (Nandi et al. 2014). Due to its high nutritious value, delicious taste and excellent flavor, low calories, it has very high demand in the world .As India is one of the largest producer and exporter of mangoes in the world that helps in increasing Nation economy. The main mango producing state in India is Uttar Pradesh producing 23.86% of complete India. In India quality testing and grading is mostly done manually. But from last decay automation in agriculture industries is playing a vital role in grading of fruit. In agriculture industries machine learning technique is providing the satisfactory results in increasing grading quality and decreasing task completion time (J. Jhawar ., 2015).

In automation technique data classification accuracy depends on collected data samples and training given to machine. Generally, there are different techniques used to train the reference samples to the grading system and then classify the new sample base on the training stage which are; statistical classification, neural network classification, fuzzylogic classification and then neural-fuzzy classification. Statistical approaches are generally characterized by having an explicit underlying probability model, which provides the probability of being in each class rather than a simple classification

#### 2. METHODOLOGY AND DATA COLLECTION

Methodology of this experiment is displayed in figure 1. MATLAB 2017 b is used for image feature extraction and classification. Rest part of this section includes data collection and image pre-processing phase for accurate dataclassification.



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# Figure 1: Methodology of classification

#### 2.1 Data collection

In this experiment total 1640 mango images are collected from a mango orchid in the same environment between May 2018 and June 2018. Mango data was collected in three stages of mango that was unripe, ripe and over ripe. The camera wasplaced at a distance of 30 cm from the sample. An individual sample image is captured two times in two directions for accurate maturity prediction. Collected data set samples are displayed.

Collected data set is divided in 80:20. 80% of dataset is used in training phase of machine and 20% is used in the testing phase of machine. In this study we also compared classification accuracy by varying number of samples used intraining phase of machine.

### 2.2 Image pre-processing

Image pre-processing is an essential part in image processing technique used to eliminate unessential information like brightness effects, illumination problem due to low contrast from image. Poor contrast images effects the segmentation accuracy. In this study, image background subtraction and image enhancement technique is used to retrieve essential information. In contrast enhancement mean and median filter is used displayed in figure2.



### 2.3 Feature extraction

Results given by machine depend on information input to the machine. In image processing field extracted features from image are used as an input to the machine on the basis of this input machine

will produce result. Essential feature extraction with accuracy will affect classification accuracy of machine learning algorithm. In this way a code book is created in the form of color features .

#### 2.4 Extracted color features

In maturity prediction of any fruit extracted color features play the vital role. RGB color model is widely used by various researchers in color feature extraction (Jhawar et al., 2015). But this model is affected with light. To increase maturity prediction accuracy a combination of RGB, HSV, HSI and L\*a\*b color model is used. In this red, green and blue color mean, hue, saturation and value mean, hue ,saturation and intensity mean and L, a and b mean is evaluated in used different color space. RGB color space intensity is used in training phase and HSV, HSI, Lab color space intensity is used in the validation phase of classification.

Image/Features	'HSV Intensity'	'HSI Intensity'	'RGB Intensity'	'LAB Intensity'
1.	0.287996379	0.24201104	32.28347778	6.61815229
2.	0.287590326	0.24631231	37.89229329	7.48424944
3.	0.287888894	0.24480399	49.20707194	9.97510529
4.	0.311031273	0.25739145	43.29288737	9.07360827
5.	0.28627501	0.24397714	38.98487854	7.98475633
6.	0.283191489	0.24385057	53.0754954	10.3671674
7.	0.302024461	0.252434	47.05983988	9.95536775
8.	0.287996379	0.24201104	32.28347778	6.61815229
9.	0.317861021	0.26965052	41.20815023	7.59829585
10.	0.284667161	0.23658692	34.52958679	6.86825127
11.	0.296919919	0.2537069	36.10286967	7.16811781
12.	0.275976049	0.23705536	44.71295675	8.31060667
13.	0.290475981	0.24321492	42.10635376	8.15619098
14.	0.283267248	0.24133717	52.02966309	9.84842122
15.	0.304775752	0.25943191	59.04716492	11.5060198
16.	0.287996379	0.24201104	32.28347778	6.61815229
17.	0.287590326	0.24631231	37.89229329	7.48424944
18.	0.302024461	0.252434	47.05983988	9.95536775
19.	0.296919919	0.2537069	36.10286967	7.16811781
20.	0.290475981	0.24321492	42.10635376	8.15619098
21.	0.317988094	0.26900545	47.77317301	8.65030307
22.	0.271884934	0.23874715	54.64713033	10.0920659
23.	0.290312287	0.24157788	35.7071991	7.68849539

 Table 1: Extracted color features

# 2.5 Geometric feature extraction

In quality testing and grading of any fruit geometric features are considered as the basic input. In this study 3 geometric features are extracted for evaluating the size of mango in enhancing classification accuracy. Extracted geometric features are:

- 1. Area
- 2. Filled area
- 3. Perimeter
- 4. Major axis
- 5. Minor axis
- 6. Orientation



# Fig3GeometricFeatures

### **3. CLASSIFICATION RESULTS**

In this research Naïve bayes and BPNN classifiers are used for classification of mangoes based on extracted color and geometric features. Classification measurement units are accuracy, sensitivity, specificity, precision and missed classification.

Accuracy	= <u>Number of corrected predictions</u>
	Total number of predictions
Precision =	<u>True positive</u>
	<i>True positive + false positive</i>
Recall =	<u>True positive</u>

*True positive +false negative* 

Sensitivity = <u>True positive</u>

*True positive+ False negative* 

# 3.1Classification results for training dataset

BPNN classifier results in training phase of machine are good and acceptable for ripe and over-ripe mangoes as compared to Naïve bayes classifier, in both cases of used features. Training dataset classification accuracy by Naïvebayes is 63.6943%, 79.6178 % and 84.0764% for un-ripe, ripe and over-ripe class respectively by using color and geometric features in classification displayed in figure 4, 66.4013. %, 75.3185% and 85.9873% for un-ripe, ripe and over-ripe class respectively by using color features only, displayed in figure 4. Classification accuracy by BPNN is 91.0032%, 91.3217% and 99.6815 % for un-ripe, ripe and over-ripe mangoes respectively in case of color and geometric features, displayed in figure 5. Classification accuracy by BPNN is 89.3412%, 86.0034% and 93.8726 % for un-ripe, ripe and over-ripe class of mango respectively in case of color features displayed in figure 6.



Figure 4: Naïve bayes classifier results based on color feature



Figure 5: BPNN classifier results based on color features

## 3.2 Classifier results for testing dataset

Testing dataset classification accuracy by Naïve bayes is 62.5995 %, 71.8833% and 83.8196% for un-ripe, ripe and over-ripe class respectively in case of color and geometric features used as an input, displayed in figure 6, 61.2307%, 72.0342% and 82.6784% for un-ripe, ripe and over-ripe class respectively displayed in figure 8. Classification accuracy by BPNN is 92.4578%, 92.7089% and 99.0634 % for un-ripe, ripe and over-ripe class respectively in case of color and geometric features, displayed in figure 7, accuracy is 90.3209%, 89.6743% and 97.5698 % for un-ripe, ripe and over-ripe class respectively in case of color and geometric features respectively in case of color and geometric features, displayed in figure 8.



Figure 6: Naivebayes classifier results based on samples



Figure 7: Naïve bayes classifier results based on features



# Figure 8: BPNN classifier results based on color features

Machine learning algorithms classification accuracy based on used samples in training phase of machine displayed in figure 8 and figure9. In used dataset 1312 used in training phase and 382 used in testing phases. After the training of machine above 700 samples classification accuracy of both classifiers is coming stable and satisfactory up to a label.

# 4.VALIDATION USING PATTERN RECOGNITION TOOL IN MATLAB

In validation we used Pattern Reorganization App of neural network. Dataset is divided in 70:15:15 in training, testing and validation. Mean square error in training, testing and validation phase is 4.5825e-4, 7.43639e-4 and 4.90390e-4 respectively. Best validation performance is .00085014 at epoch 1000 displayed in figure 13.Regression graph of data classification is displayed in figure 9.



Figure 9: Neural network training performance graph

#### **5. CONCLUSION AND FUTURE WORK**

This study concluded that results provided by BPNN are satisfactory and acceptable in comparison of Naïve bayes in both case of used features. Classification accuracy is also influenced with the used training samples in machine learning algorithms. BPNN is considered the best classifier which confirmed by zero differences between results obtained in the test series. Classification accuracy is up to 99.08% in over-ripe class that is considered the poor quality class of mangoes. In case of un-ripe (average quality class) and ripe (good quality class) of mangoes this classification accuracy is switching between 91.05% and 90.34%. In future we will work on to improve these class classification accuracy. One more problem phased in this study is the variation of classification accuracy in retraining neural network again and again. In future we will also try to resolve this problem by using some optimizing algorithms with BPNN.

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