Fruit Identification using Multi-Class SVM

Chirag C. Patel[1], Dr. Vimal K. Chaudhari[2]
[1]UCCC & SPBCBA & SDHG College of BCA & I.T., Udhna, Surat
[2]Department of Computer Science, Veer Narmard South Gujarat University, Surat
(E-mail: chirag3153@gmail.com)

Abstract**—**An automatically Fruit Identification is a challenging task of computer vision because different fruits may have the same color and shape and different images have different size and scale. In this paper, fruit identification is proposed based on Color, Zone, Area, Centroid, Size, Equvidiameter, Perimeter, and Roundness features using Multi-Class SVM classifier. In this research Apple, Banana, Orange, Pear, Watermelon and Mango fruits categories are used. In the research, 162 images of mentioned fruits are used from that 138 images are used for training and 24 images are used to test model. Fruit images are downloaded from different websites. The proposed method performs Image Acquisition, Pre-processing, Feature Extraction, Train model. These steps are followed in MATLAB tool and then exported feature dataset to WEKA and Orange Canvas tool to further compare the performance of classifiers in all three tools, to measure classifiers performance Detail Accuracy, Confusion Matrix and ROC Analysis criteria are considered. Based on proposed features the accuracy of Multi-Class SVM is 87.5% in WEKA, 91.67% in MATLAB and 91.7% Orange canvas tools, confusion matrix and ROC analysis charts of all three data mining tools shows that Multi-Class SVM is an efficient classifier for proposed features.

Keywords**—***Fruit Identification; Image Recognition; Image Classification, SVM, Multi-Class SVM*

I. INTRODUCTION

Automatic fruit identification system can be considered as image descriptor because it contains visual features of the images. It is the task of identifying an object from images without or less human interaction, to identify objects from images it needs focus on images size, scale, position, and orientation because all images have different size, scale, position and orientation of fruit objects. Any computer vision system contains stages of 1) Image representation: is the task of digitizing image or image conversion from analog to digital. 2) Pre-processing: is the stage of image enhancement and noise removal from images. It is the process of correcting irregularity of sensors, removal of noise and conversion of data to accurately represent image [1]. 3) Segmentation: is the process of finding the interest of area in the image 4) Description: is the task if extracting features from images and 5) Recognition: on the basis of the description of images, it recognizes images [2]. In past years many researchers have proposed several automatic fruit identification approaches, most of them are based on color and shape features of the fruits but different fruits may have same color or shape which will not that much effective approach to identify fruit images and it reflect the accuracy of the system. To overcome this situation and identify fruit images accurately in this paper Color, Zone, Area, Centroid, Size, Equvidiameter, Perimeter and Roundness features of fruit images are used and classify images Multi-Class Support Vector Machine (One versus all) machine learning algorithm is used. In this studies, Multi-Class SVM classifier is selected because in the previous study comparison of SVM, KNN, Naive Bays, Random Forest, and Neural Network classifier have been performed for Apple fruit and it found that Multi-Class SVM is an efficient classifier among all compared classifiers [3].

SVM is the supervised machine learning algorithm for regression analysis and data categorization, it was introduced for the two-class classification problem, it will take vectors as input and mapped it with non-linear high dimension feature space which will create decision surface [4]. SVM will reduce empirical error and maximize geometric margin so that it is also called maximum margin classifier [5]. It can also be used for multiclass classification, there are three ways for multiclass classification for SVM: **1) one against one:** is also called paired wise decomposition, it will build K (K - 1) / 2 binary SVM models. For test data, each SVM model provides votes to winning class and test data labeled with the class having most votes. **2) one against all:** it constructs K separate binary classifiers models for K-classes for classification. Training of classifier models has been performed as the manner of binary class that is for m-binary model m-th class examples are positive and remaining K-1 classes are negative. In this approach ratio of positive to negative is 1 / k – 1. **3) Directed acyclic graph:** its training phase is the same as one-against-one method but only difference is in testing phase, it uses rooted binary directed acyclic graph that forms structure like tree so it will take K – 1 individual evaluation to decide label for testing. Tree structure contains internal nodes of the classes and by using binary decision function it is evaluated, as per output it will decide in which direction to be moved either left or right and leaf node of the tree will be considered as predicted class [6 - 7]. One against all approaches is used for the proposed system, in the proposed system Apple, Banana, Orange, Pear, Watermelon and Mango six different fruit categories are used to create SVM training model and to test model, to train model Supervised learning approach is used. Supervised learning is the mapping between input and output and based on mapping it will predict the output for hidden data. Supervised learning performed based on supervisor's instructions, it will associates labels to training data. Labels are the class labels of classification, supervised learning will create a model that can be used to classify unlabeled other data [8].

II. RELATED WORK

R. M. Bolle and others have approached Veggie Vision produce recognization. It was introduced in 1996, it is based on color, shape and density features. It is an automatic produce ID system that eases the produce checkout process. İt was introduced for supermarket and grocery stores. It takes the image of produce items when it put on the scale because on the top of scale camera is fitted, once image taken features are going to be extracted from taken images. Authors have used Nearest Neighbor classifier for classification, and they found 95% accuracy in the first four choices [9]. Deepika Shukla and Apurva Desai have suggested fruit identification based on color, size, shape, and texture based features, features have been passed to two classifiers KNN and Multi-class SVM classifiers. They have used 132 images of Apple, Banana, Indian Lemon, Mango, Pear, Plum, Orange and Strawberry of fruits to train both classifiers and 23 images of mentioned classes to test both classifiers and found 91.3 accuracies for KNN and 86.96% accuracy for Multi-Class SVM [10]. S. Arivazhagan and others have approached fruit identification based fusion of color and texture features. Authors have converted RGB images to HSV images and then extracted statistical and characterized features. They have used minimum distance classifier and used 2635 fruits and vegetable images of Agata Apple, Asterix Apple, Cashew, Diamond Peach, Fuji Apple, Granny Smith, Honeydew Melon, Kiwi, Nectarine, Onion, Orange, Plum, Spanish Pear, Taiti Lime and Watermelon from that 1314 images for training and 1326 images for testing and found 86.004% accuracy [11]. Shiv Ram Dubey and Anand Singh Jalal have suggested state-of-art color and texture based features for fruit identification. Authors have extracting features and then combined them for efficient feature description. They have used Multi-class support vector classifier and K-mean clustering based image segmentation to subtract the background and found 93.84% accuracy [12]. Yudong Zhang and Lenan Wu have suggested color histogram, unser's texture and shape based features and used Multi class kernel SVM classifier for classification. To subtract backgrounds from images split and merge algorithm is used. They have used 1653 images of eighteen different categories of fruits from that 1322 is used for training and 331 images are used for testing and applied 5-fold cross-validation on training data [13]. Michael Vogl and others have proposed color, shape, and texture based features. Authors have extracted features and transform them as a unique code that can be used as a search key, it will search for a closet match using distance table. They have used otsu algorithms to remove backgrounds. They have used 1108 images of 36 different classes and found 98% of accuracy [14]. Hossam M. Zawbaa and others proposed shape, color, and Scale Invariant Feature Transform (SIFT) based features using Random Forest classification. Authors have used 178 fruit images of Apple, Orange and Strawberry fruit images from those 60% images are used for training and 40% images are used for testing and found 94.74% accuracy for apple, 85.71% accuracy for strawberry and 50% accuracy for orange [15]. Woo Chaw Seng and Seyed Hadi Mirisaee have proposed color, shape and size features based. Authors have used 50 fruit images of six different fruit categories from that 36 images are used for training and 14 images are used for testing. They have used K-NN classifier for classification and found 90% accuracy [16]. Pragati Ninawe and Mrs. Shikha Pandey have proposed shape, size, color and texture features based. They have used K-NN classifier in that K=1 which means the classification is based on stored images. They have used 36 images of six different fruit classes from that 24 images were used for training and 12 images are used for testing and found 95% accuracy [17]. Susovan Jana and Ranjan Parekh have suggested shape feature based. They have used Naive Bayes, Neural Network and K-NN classifiers for classification. They have made a comparison between the three classifiers. They found 95.24% accuracy for Naive Bayes, 91.43% accuracy for Neural Network and 88.57% accuracy for K-NN classifiers. They have used 210 images of seven different categories of fruits from that 15 images for training and 15 images for testing each category [18]. Hu-Lin Kuang and others have suggested Multi-feature fusion of global color histogram, Local Binary Pattern, Histogram of Oriented Gradient and LBP based on Gabor Wavelet features. They have used LibSVM classifier for classification, and they have used 1778 images if five different classes [19]. Saswati Naskar and Tanmay Bhattacharya have suggested texture, color, and shape based approach, to extract texture Gabor filter is used, to extract color mean hue is used and for shape counting perimeter and area pixel is used. They have used Artificial Neural Network for classification. They have used 150 fruit images of six different categories and found 90% of accuracy [20].

III. METHODOLOGY

Fig.1 shows proposed methodology steps of fruit identification, the proposed approach of fruit identification is based on Color, Zone, Area, Centroid, Size, Equvidiameter, Perimeter, and Roundness features, to perform experiment MATLAB, Weka and Orange canvas tools are used. MATLAB will generate proposed feature data set that will be used in all three tools to create train and test model of Multi-Class SVM. All three tools are used to compare the accuracy of the model.

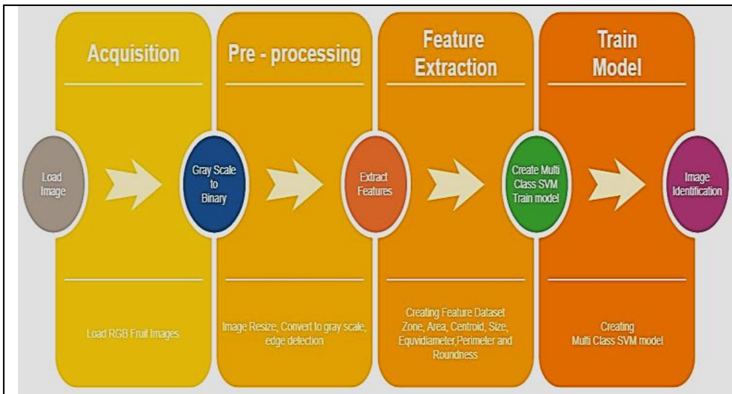

Fig. 1 Methodology of Fruit Identification

- *Acquisition:* it is the task to load or read RGB images and provide it to the system for further processing, to read images the user has to provide a folder path where RGB fruit images are, the system will read all the images from folder one by one, to read RGB images Matlab tool is used. MATLAB will read images and return a two-dimensional array of Rows and Columns which represents the intensity of each pixel of images that can be used for processing.

- *Pre-processing:* any computer vision system needs to perform pre-processing on images because every image has different scale and size of the images so to accurately extract features from images every computer vision systems need to perform Image Pre-processing. Fig.2 shows the process flow of the image pre-processing.

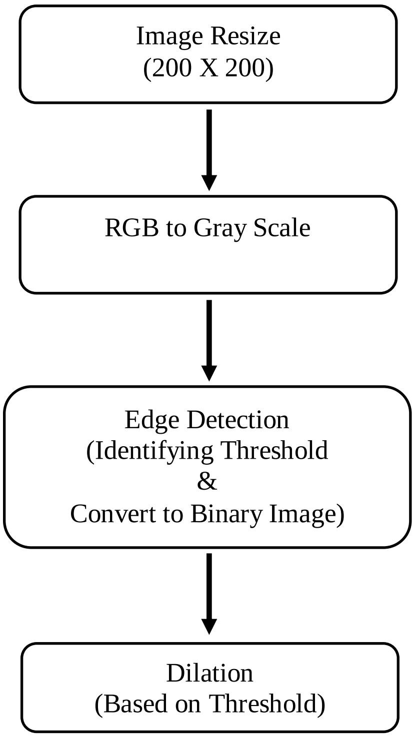

Fig. 2 Process Flow of Image Pre-processing

  - *Image Resize:* every image is different in scale and size, so it needs to create all images in the same size to accurately extract features from images. Once RGB images are loaded then, it can be resized to 200 X 200 pixels by using MATLAB resize function.
  - *RGB to Gray Scale:* images are resized then it needs to convert RGB image to Gray Scale to identify edges of the images. Grayscale images contain colors of shades, and gray color has equal intensity of the Red, Green and Blue color so edges can be detected efficiently.
  - *Edge Detection:* edge detection is used to find the interested area of the images from Grayscale images, Canny edge detection algorithm is used to find edges from Grayscale, edge detection will convert grayscale image to black and white images. As per edges, the threshold can be calculated. It will convert images into binary images which contain fruit area of the fruit images.
  - *Dilation:* based on the threshold calculated through edges dilation operation apply which will make interested fruit area thicker which will make interested are clearer.

- *Feature Extraction:* is the process of extracting visual contents from the images. Features have been extracted after applying to pre-process on the image but the only color feature will be extracted from RGB images.
  - *Color:* a color feature will play a key role to identify fruits, to calculate color Mean of the image is used. Mean can be calculated by using Mean function in Matlab. It will also calculate the mean of the matrix. To calculate color accurately proposed methodology is once images are resized, five small samples from resized RGB images have been cropped, then mean is calculated of all five cropped images and then again mean is calculated of all five means. Cropped images samples have been taken from Top, Bottom, Middle, Left and Right of resized RGB images.
  - *Zone:* binary images contain an interested area that is fruit region of the images which contains 0s and 1s in the matrix. Fruit region will divide into four quadrants and from each quadrant percentage of images have been calculated.
  - *Area:* area of fruit is calculated from binary images. It is the analysis of the row pixels. It can be calculated using the numel function of MATLAB.
  - *Centroid:* it is the average mean pixels of the rows and columns. It can be calculated by finding the mean of row pixels and column pixels. It is an average mean of row major axis length and the average mean of column minor axis length.
  - *Size:* is the height and width of area, it can be calculated by creating a bounding box around the area of the fruit of binary images. It can be calculated by finding breadth and length of the box, then breadth and width will be added with

starting pixel from that it will create a box around fruit area as per the size of breadth and length.

- *Equvidiameter:* it is the diameter of the fruits region area of the binary images. İt can be calculate using sqrt(4 * (Obj_area) / pi) formulation where Obj_area is the area of the fruits.
- *Perimeter:* it is the distance of fruit area, it can be calculated by finding the area between each neighbor pair pixel of borders of fruit area.
- *Roundness:* it is shaped gross feature, it is surface roughness of fruit area. İt can be calculate using (4 * Obj_area * pi) / Per .^ 2 formulations.

- *Train Model:* it is the task to create a model of the features dataset which have been extracted in Feature Extraction task, feature extraction will provide two dimensional arrays of feature dataset, to train model total number of 138 images are used for Apple (22), Banana (27), Orange (25), Pear (23), Watermelon (21) and Mango (20) fruits categories, as mentioned earlier Multi-Class SVM classifier is used for proposed method so here in model creation task Multi-Class SVM model is created by applying one against all approaches to train SVM classifiers. SVM model has been created of six classes of fruits in MATLAB, Weka and Orange Canvas tools. In Weka and Orange Canvas tools, models have been created by using MATLAB feature dataset, from MATLAB dataset is exported as excel file and provided to Weka and Orange Canvas on the basis of that file both tool have created SVM models. In the Weka by using Knowledge Flow tool SVM model have been created and in Orange Canvas is the visual programming analytical tool so it will create an SVM model by using visual tools of Orange.
- **Image Identification:** once the model has been created it needs to test a model by providing images which were not present in the training samples and find out does it accurately identifying it or not. For image identification whatever images are provided by a user it needs to extract features extracted for training and than it will also provide two dimension arrays that will be passed to the model to classify the images, to test model 24 images are used for Apple (5), Banana (4), Orange (4), Pear (5), Watermelon (4) and Mango (2). Image identification is also done in all three tools that are MATLAB, Weka and Orange Canvas same as feature data set of test images exported to Weka and Orange Canvas to test created model.

IV. EXPERIMENTS AND RESULTS

The experiment was performed in MATLAB, Weka and Orange canvas, to evaluate classifier 162 images are used from that 138 images of Apple (22), Banana (27), Orange (25), Pear (23), Watermelon (21) and Mango (20) fruits categories are used to train model and 24 images of Apple (5), Banana (4), Orange (4), Pear (5), Watermelon (4) and Mango (2) are used to test classifier.

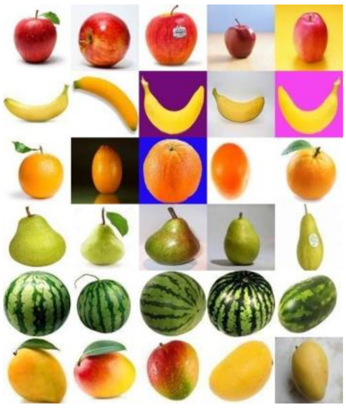

Fig. 3 Sample Images to Train Classifier model

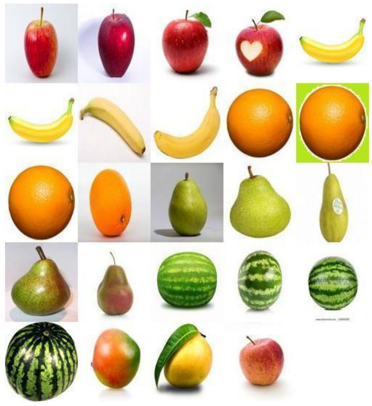

Fig. 4 Sample Images to Test Classifier model

Above Fig.3 and Fig.4 shows sample images of fruits image, which was used to train and test the Multi-Class SVM model in MATLAB, Weka and Orange Canvas tools.

	TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area
SVM	0.875	0.025	0.900	0.875	0.865	0.855	0.946	0.805

Tab.1 Detail Accuracy of Model in Weka

Method	CA	F-Measure	Precision	Recall
SVM	0.9167	0.9220	0.9333	0.9111

Tab.2 Detail Accuracy of Model in MATLAB

Test & Score

Settings

Sampling type: No sampling, test on testing data
Target class: Average over classes

Scores

Method	AUC	CA	F1	Precision	Recall
SVM	0.859	0.917	0.914	0.940	0.917

Tab.3 Detail Accuracy of Model in Orange Canvas

Above Tab.1, Tab.2 and Tab.3 show detail accuracy of the Multi-Class SVM model in all three tools. Its fields are AUC (Area Under ROC), CA (Classification Accuracy), F1 (balanced F-Score or F-Measure score), Precision is the proportion of instances based on the positive categorized by classifier divided by overall in that category, Recall is instances classified as a given class divided by the actual total in that class, TP Rate is true positives rate, FP Rate is false positives rate, MCC stands for the Matthews correlation coefficient. Detail Accuracy of the classifiers shows that SVM has 87.5%, 91.67 and 91.7%.

➢ **Confusion Matrix for SVM**

	Apple	Banana	Orange	Pear	Watermelon	Mango
Apple	5	0	0	0	0	0
Banana	0	4	0	0	0	0
Orange	0	0	4	0	0	0
Pear	0	1	0	3	1	0
Watermelon	0	0	0	0	4	0
Mango	0	0	1	0	0	1

Tab.4 Confusion Matrix of Model in Weka

➢ **Confusion Matrix for SVM**

	Apple	Banana	Orange	Pear	Watermelon	Mango
Apple	5	0	0	0	0	0
Banana	0	4	0	0	0	0
Orange	0	0	4	0	0	0
Pear	0	0	1	3	0	1
Watermelon	0	0	0	0	4	0
Mango	0	0	0	0	0	2

Tab.5 Confusion Matrix of Model in MATLAB

Confusion matrix for SVM (showing number of instances)

		Predicted						
		Apple	Banana	Mango	Orange	Pear	Watermelon	∑
Actual	Apple	5	0	0	0	0	0	5
	Banana	0	4	0	0	0	0	4
	Mango	0	0	2	0	0	0	2
	Orange	0	0	1	3	0	0	4
	Pear	0	0	1	0	4	0	5
	Watermelon	0	0	0	1	0	3	4
	∑	5	4	4	4	4	3	24

Tab.6 Confusion Matrix of Model in Orange Canvas

Above Tab.4, Tab.5 and Tab.6 show confusion matrix in WEKA, MATLAB, and Orange canvas tools. Confusion Matrix will show occurrences in the target category and individual row shows occurrences in output class. Every element of rows and columns shows the occurrences of a jth category that categorized as an ith class. All three data mining tools show that Multi-Class SVM classifier is efficiently identifying images based on proposed features.

Below Fig.5 – Fig. 10 describes ROC analysis charts of Apple, Banana, Orange, Pear, Watermelon and Mango fruits in WEKA data mining tool. ROC analysis depends on Positive occurrences indifference of Negative occurrences as per different thresholds.

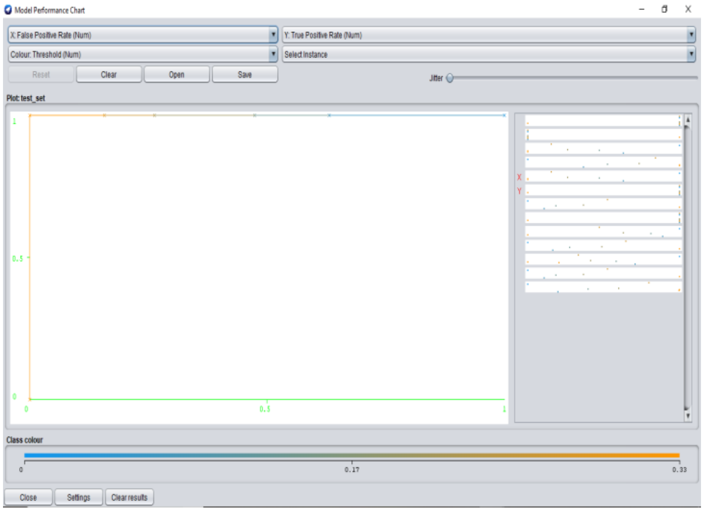

Fig. 5 ROC Analysis Chart of Apple fruit in WEKA

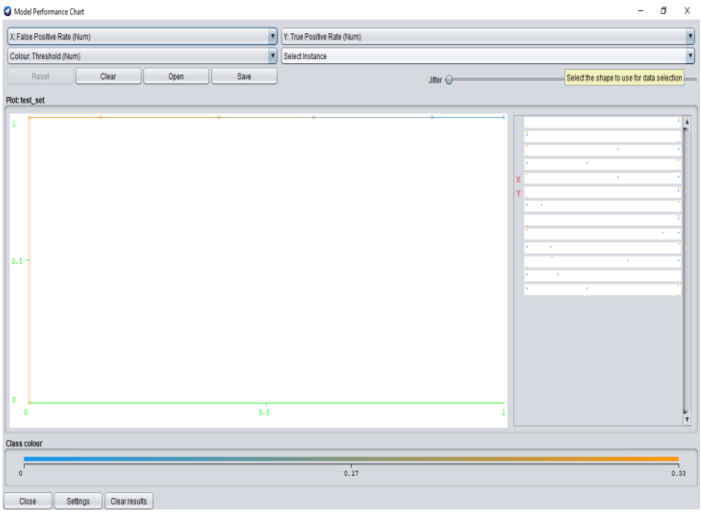

Fig. 6 ROC Analysis Chart of Banana fruit in WEKA

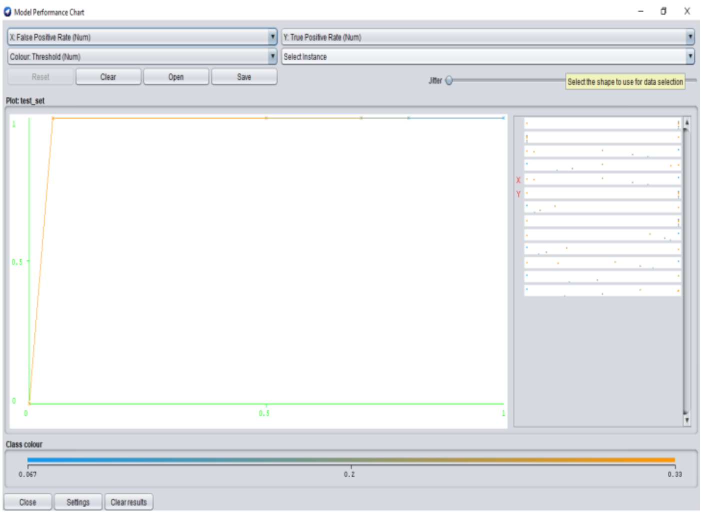

Fig. 7 ROC Analysis Chart of Orange fruit in WEKA

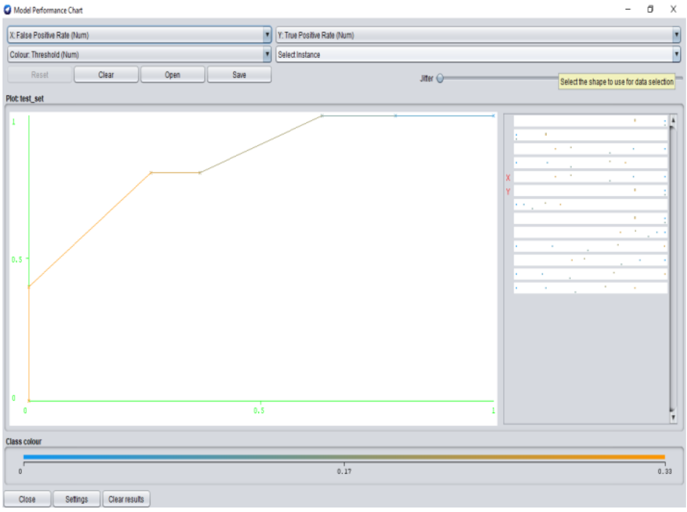

Fig. 8 ROC Analysis Chart of Pear fruit in WEKA

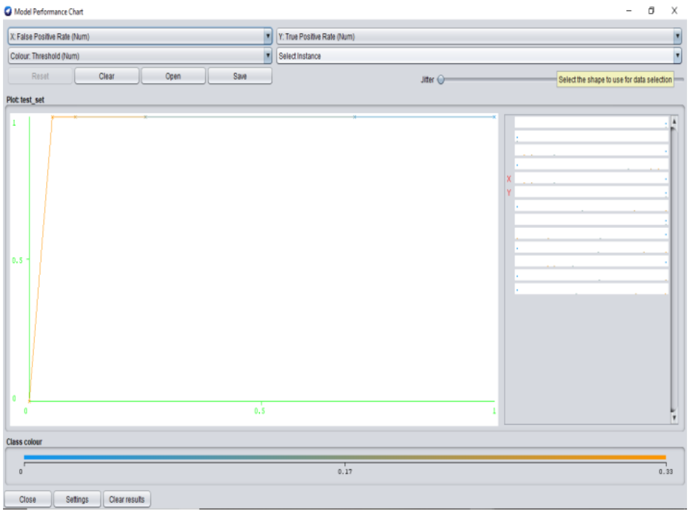

Fig. 9 ROC Analysis Chart of Watermelon fruit in WEKA

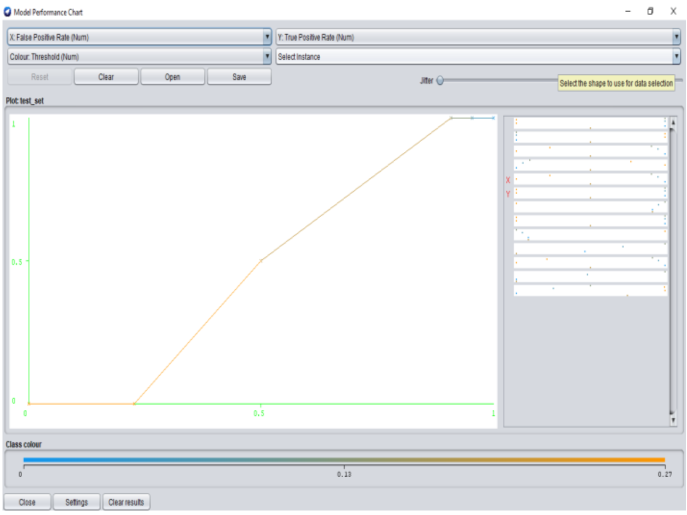

Fig. 10 ROC Analysis Chart of Mango fruit in WEKA

Below Fig.11 – Fig. 16 describes ROC analysis charts of Apple, Banana, Orange, Pear, Watermelon and Mango fruits in MATLAB tool.

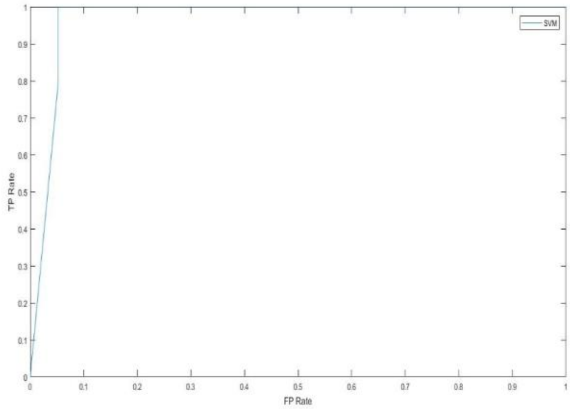

Fig. 11 ROC Analysis Chart of Apple fruit in MATLAB

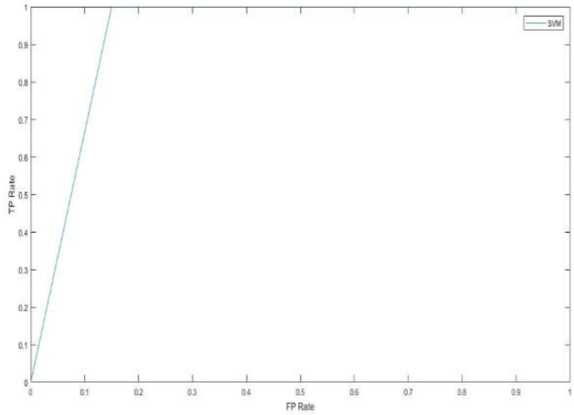

Fig. 12 ROC Analysis Chart of Banana fruit in MATLAB

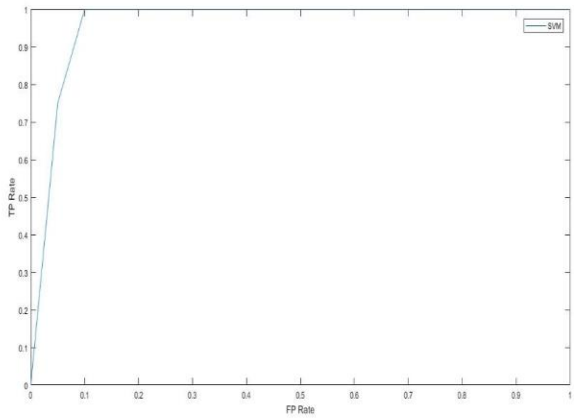

Fig. 13 ROC Analysis Chart of Orange fruit in MATLAB

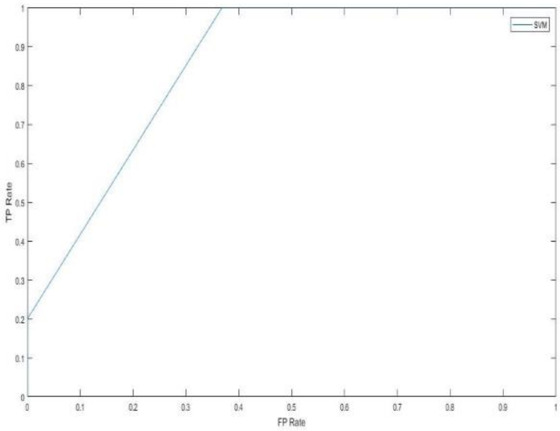

Fig. 14 ROC Analysis Chart of Pear fruit in MATLAB

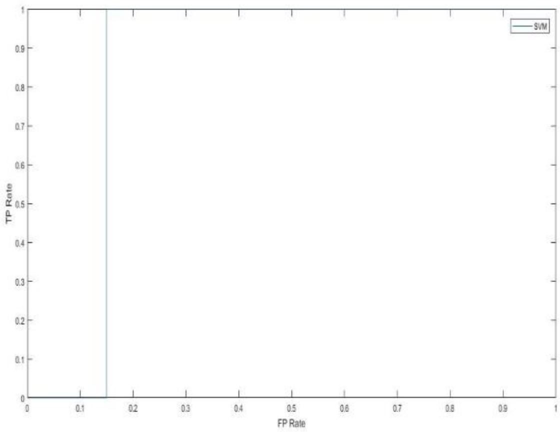

Fig. 15 ROC Analysis Chart of Watermelon fruit in MATLAB

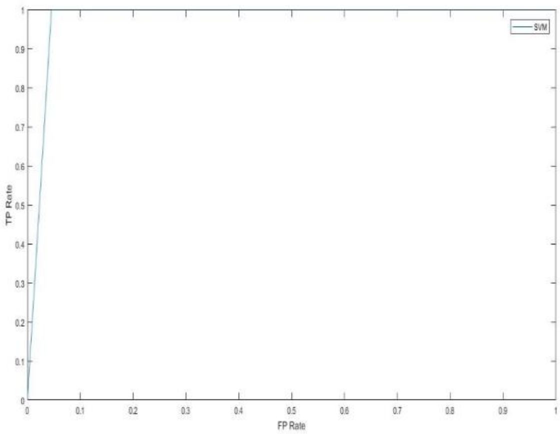

Fig. 16 ROC Analysis Chart of Mango fruit in MATLAB

Below Fig.17 – Fig. 22 describes ROC analysis charts of Apple, Banana, Orange, Pear, Watermelon and Mango fruits in Orange Canvas tool.

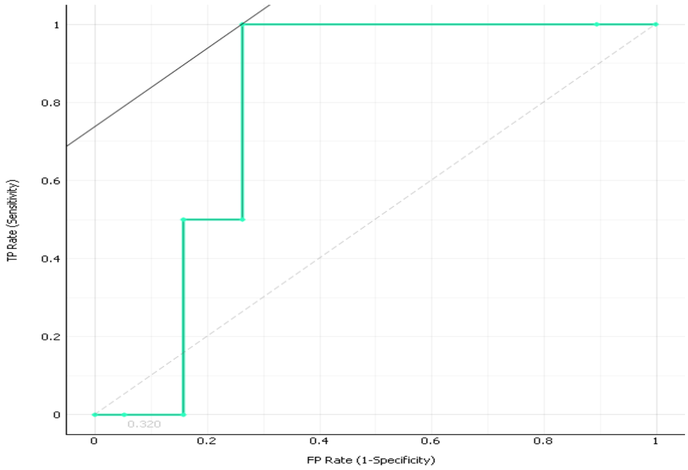

Fig. 17 ROC Analysis Chart of Apple fruit in Orange Canvas

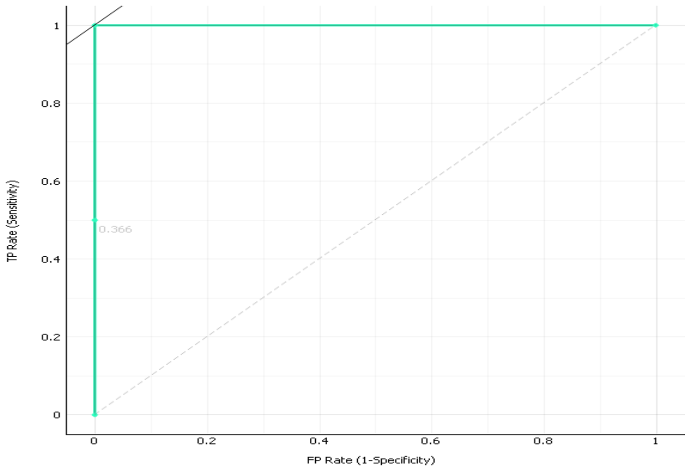

Fig. 18 ROC Analysis Chart of Banana fruit in Orange Canvas

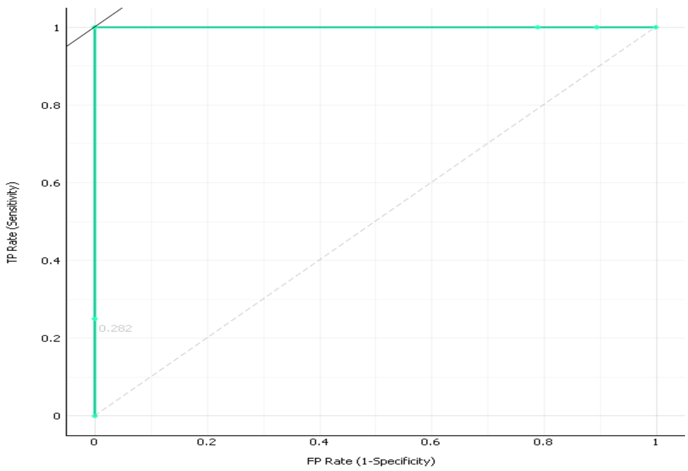

Fig. 19 ROC Analysis Chart of Orange fruit in Orange Canvas

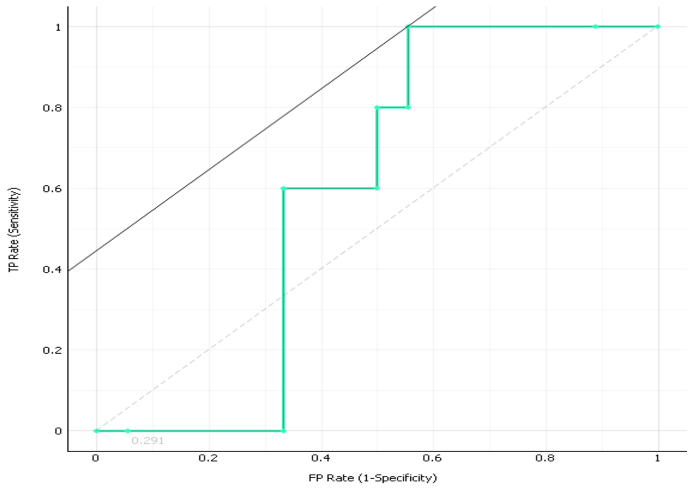

Fig. 20 ROC Analysis Chart of Pear fruit in Orange Canvas

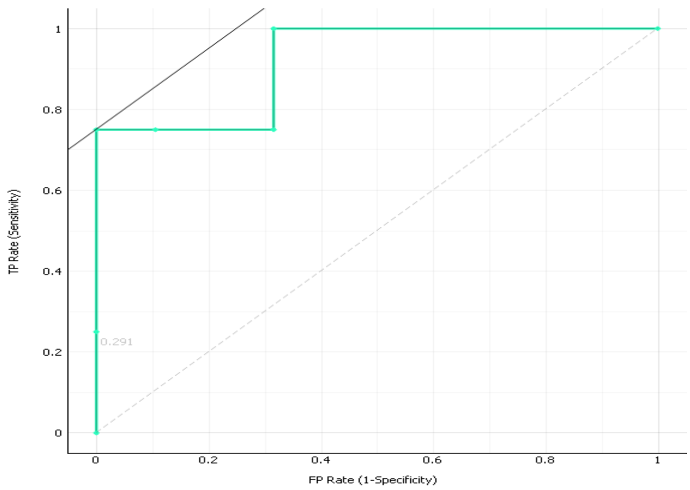

Fig. 21 ROC Analysis Chart of Watermelon fruit in Orange Canvas

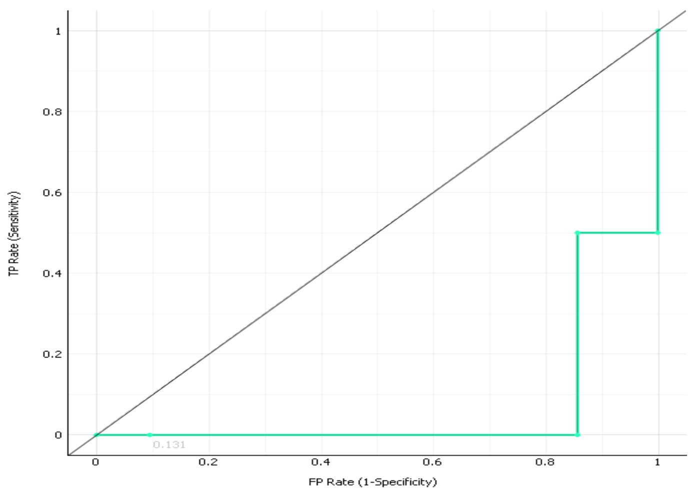

Fig. 22 ROC Analysis Chart of Mango fruit in Orange Canvas

V. CONCLUSION

In this studies, Fruit identification is performed on Multi-Class SVM classifier based on Color, Zone, Area, Centroid, Size, Equvidiameter, Perimeter, and Roundness features and achieved 87.5% in WEKA, 91.67% in MATLAB and 91.7% Orange Canvas. In this study WEKA and Orange Canvas are used to make a comparison of Multi-Class SVM with MATLAB model accuracy. It shows that all three tools have almost similar accuracy. Confusion matrix and ROC analysis chart of all three tools of Apple, Banana, Orange, Pear, Watermelon, and Mango fruits are also shown that the performance of Multi-Class SVM is efficient. From this study, it can be concluded that Multi-Class SVM is an efficient classifier for proposed features.

REFERENCES

[1] G. Eason, B. Noble, and I.N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” Phil. Trans. Roy. Soc. London, vol. A247, pp. 529-551, April 1955. (*references*)

[2] Ms.A.Pritha and D.Santhi Jeslet, “A study on sampling and quantization techniques of image processing,” National Conference on Prominent Challenges in Information Technology (PCIT) organized by Computer Science Technical Association (ComSTA), 8th Dec 2015

[3] Prof. Deepika Shukla and Apurva Desai, “Review on generic object recognition techniques: challenges and opportunities,” International Journal of Advanced Research in Engineering and Technology (IJARET) Volume 6, Issue 12, Dec 2015, pp. 104-133

[4] Chirag Patel and Dr. Vimal K. Chaudhari, “Comparative study of different classifiers: an apple fruit as case study,” International Journal of Creative Research Thoughts (IJCRT) 2017 IJCRT | Volume 5, Issue 3 September 2017

[5] Corinna cortes and Vladimir vapnik, “Support-Vector Networks Machine Leaming,” 20, 273-297 (1995) ~) 1995 Kluwer Academic Publishers, Boston. Manufactured in The Netherlands

[6] Durgesh k. Srivastava and Lekha bhambhu, “Data classification using support vector machine,” Journal of Theoretical and Applied Information Technology

[7] Chih-Wei Hsu and Chih-Jen Lin, “A Comparison of Methods for Multiclass Support Vector Machines,” IEEE transactions on neural networks, vol. 13, no. 2, March 2002

[8] Zhe Wang and Xiangyang Xue, “Multi-Class Support Vector Machine,” Y. Ma and G. Guo (eds.), Support Vector Machines Applications Springer International Publishing Switzerland

[9] P´adraig Cunningham, Matthieu Cord, and Sarah Jane Delany, "Supervised Learning," Machine Learning Techniques for Multimedia 2008

[10] R. M. Bolle, J. H. Connell, N. Haas, R. Mohan, and G. Taubin, "Veggievision: A produce recognition system," Applications of Computer Vision, 1996. WACV'96., Proceedings 3rd IEEE Workshop on. IEEE, 1996.

[11] Deepika Shukla and Apurva Desai, "Recognition of Fruits Using Hybrid Features and Machine Learning," 2016 International Conference on Computing, Analytics and Security Trends

[12] S.Arivazhagan, R.Newlin Shebiah, S.Selva Nidhyanandhan, and L.Ganesan, "Fruit Recognition using Color and Texture Features," Journal of Emerging Trends in Computing and Information Sciences VOL. 1, NO. 2, Oct 2010

[13] Shiv Ram Dubey and Anand Singh Jalal, "Fruit and vegetable recognition by fusing color and texture features of the image using machine learning," International Journal of Applied Pattern Recognition Vol. 2, No. 2, 2015

[14] Yudong Zhang and Lenan Wu, "Classification of Fruits Using Computer Vision and a Multiclass Support Vector Machine," Sensors 2012

[15] Michael Vogl, Jang-yoon Kim, and Shin-Dug Kim, "A Fruit Recognition Method via Image Conversion optimized through Evolution Strategy," 2014 IEEE 17th International Conference on Computational Science and Engineering

[16] Hossam M. Zawbaa, Maryam Hazman, Mona Abbass and Aboul Ella Hassanien, "Automatic fruit classification using random forest algorithm," 2014 International Conference on Hybrid Intelligent Systems

[17] Woo Chaw Seng and Seyed Hadi Mirisaee, "A New Method for Fruits Recognition System," 2009 International Conference on Electrical Engineering and Informatics

[18] Pragati Ninawe and Mrs. Shikha Pandey, "A Completion on Fruit Recognition System Using K-Nearest Neighbors Algorithm," International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) Volume 3 Issue 7, July 2014

[19] Susovan Jana and Ranjan Parekh, "Shape-based Fruit Recognition and Classification," Springer Nature Singapore Pte Ltd. 2017 J.K. Mandal et al. (Eds.): CICBA 2017, Part II, CCIS 776, pp. 184–196, 2017

[20] Hu-Lin Kuang, Leanne Lai Hang Chan and Hong Yan, "Multi-class fruit detection based on multiple color channels," 2015 International Conference on Wavelet Analysis and Pattern Recognition (ICWAPR) Date Added to IEEE Xplore: 12 October 2015

[21] Saswati Naskar and Tanmay Bhattacharya, "A Fruit Recognition Technique using Multiple Features and Artificial Neural Network." International Journal of Computer Applications (0975 – 8887) Volume 116 – No. 20, April 2015

Chirag Patel
Assistant Professor

UCCC & SPBCBA & SDHG College of BCA & I.T., Udhna, Surat
E-mail: chirag3153@gmail.com

He received the Master of Computer Application from SRIMCA, VNSGU, Surat. He is currently pursuing his Master of Philosophy from VNSGU, Surat. His research interests include image processing and machine learning. He is an assistant professor at UCCC & SPBCBA & SDHG College of BCA & I.T. since Jan-2010.

Dr. Vimal K. Chaudhari
Assistant Professor

Department Of Computer Science,
Veer Narmad South Gujarat University,
UM Road, Vesu, Surat
Tel: 0261-2257911,2257906
E-mail: vimal@vnsgu.ac.in

Vimal Chaudhari was born in Surat, India, in 1978. He received the B.E degree in Mechanical Engineering from Sardar Vallabhbhai Patel Regional Engineering College, Surat, in 1999, and the M.C.A from VNSGU in 2002 and Ph.D degree in Computer Science from Veer Narmad South Gujarat University (VNSGU), Surat in 2011.

In 2004, he joined the Department of Computer Science, Veer Narmad South Gujarat University, as Assistant Professor. His current research interests are data mining and web mining. He has written four research papers and two books. He has attended 10 + national and International workshops and seminars. He has been associated with MCA and PGDCA science last 12 years. He has been teaching subjects like PHP, VB.Net, C, Operation Research and Object Oriented Programming. He is member of various Administrative committees like SC-ST cell and Syllabus committee of various courses of computer science.