American-Eurasian Journal of Scientific Research 11 (3): 169-176, 2016
ISSN 1818-6785

DOI: 10.5829/idosi.aejsr.2016.11.3.22791

Multi Level Intensity Estimation Technique Based Fruit Grading Using Template Matching and Fuzzy Rule Sets

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Abstract: To solve the problem of fruit grading, the researchers discussed different approaches but suffers with the false classification rate and the methods are scalable in accuracy. To overcome the problem of false classification, an novel multi level intensity estimation technique has been proposed to perform fruit grading. The method uses intensity values of fruit image and uses the shape features of the image to perform classification. Based on the shape and intensity features, the method maintains a set of templates for the shapes and the classification is performed using the intensity estimation technique. The method converts the extracted features into number of rule sets, which will be used to perform classification. The extracted features are categories into number of classes as shapes and intensity values of different fruits. For any input image, the same feature extraction is performed and the method computes the multi level intensity estimation technique and template matching process to classify the image or to decide the grade of fruit. The proposed method achieves great effort in fruit grading with more accuracy and reduces the problem of false classification. Also the method reduces the time complexity of fruit grading.

Key words: Template Matching · Intensity Estimation · Fuzzy Rule Sets · Image Processing · Fruit Grading

INTRODUCTION

Image processing- a huge topic of research which has impact in various domain of problems and can be adapted for any problem to come up with the solution. The image processing techniques can be applied for fruit grading problem where the input image is a fruit and the fruit present in the image may be of with any quality according to the shape and color [1]. Sometimes the fruit may be in good grade which tell that the fruit has all the qualities of the fruit respect to the features present in the rule set. For example, the image is a an apple image, then the shape of the object present in the image can be extracted using the image processing technique and also based on the color values we can conclude the condition of the fruit. The image processing technique provides the way to perform all these tasks on the fruit image and even the image can be improved for its quality before proceeding with feature extraction [2].

Template matching is a process of image processing where the method maintains different shape features of different objects. The method maintains number of shape features for the same class of objects and when a new image object or a shape is given; the method can perform matching process with the existing class of templates and their samples. By performing matching process, the method can identify the class of the object to which it belongs. This kind of template matching approaches is more applicable in many problems from face recognition to the different image classification approaches. The same can be applied to the problem of fruit grading where each fruit has its own shape by varies with the size [3].

Intensity is the important feature of any image which is decided by the color values of any image. All the fruits have their own colors, for example the apple looks in red and pink colors, where the banana looks in yellow. Similarly every fruit has their own color features and the color features varies according to their grade. For example, if the apple looks with more pink or red then the grade of the fruit will be higher. Similarly, if the banana looks with high intensity yellow then we can assign higher grade for the fruit. Not only this, the same color feature can be used to identify the damages present in the fruit, because when the apple or banana gets damaged then we can see the unbalanced color values in the fruit image. For example if

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the banana has become older and gets damaged in some places then we can see more black pixels in the region where the damage is present. Generally the presence of black pixels represents the damage of the fruit in the image, which could be used to perform fruit classification or fruit grading [4].

The fuzzy rule sets are one which maintains a set of patterns with number of attributes where each attribute has range of values. Similarly the fruit features can be converted into fuzzy rules, where the features of the rules are color values like green, red, black, yellow and the shape features can be included into the rule base. By maintaining such rule sets, the grading or classification of fruit images can be performed in efficient manner. For the same fruit there may be N number of rule present in the rule base and based on the number of rule available the class of the fruit can be identified. Because there may be M number of class present or grade present for the same fruit image [5].

Automated Mango Fruit Grading System Using Fuzzy Logic [6-13], has been discussed which uses fuzzy logic to create a novel grading method. A membership function and fuzzy rules are generated from training instances based on minimum entropy formulas. Computer and Red Green and Blue (RGB) fiber optic sensor are used to examine and clarify data corresponding to human judgment and intelligence.

Related Works: There are many approaches has been discussed for the problem of fruit grading and fruit image classification. We discuss few of them here in this section.

Image segmentation method for apple sorting and grading using support vector machine and Otsu's method [1], adjusts the classification hyper plane calculated by using linear SVM and requires minimum training and time. It also avoids the problems caused by variations in the lighting condition and/or the color of the fruit. To evaluate the robustness and accuracy of the proposed segmentation method, tests were conducted for 300 'Delicious' apples using three training samples with different color characteristics (i.e., orange, stripe and dark red) and their combination.

Image segmentation, which separates the product region from background in the image, is one of the most important tasks in image processing since it is the first step in image analysis after the image capture to subdivide an image into meaningful regions. The segmentation result affects the subsequent image analysis. For instance, Non-destructive technologies for fruit and vegetable size determination [2], the estimation of product size and shape is directly affected by the segmentation result because these morphological features are usually obtained based on the product contour information.

In-line sorting of irregular potatoes by using automated computer-based machine vision system [4], was conducted to develop a fast and accurate computer-based machine vision system for detecting irregular potatoes in real-time. A database of images was first formulated from potatoes with different shapes and sizes and then some essential geometrical features such as perimeter, centroid, area, moment of inertia, length and width were extracted from each image. Also, eight shape parameters originated from size features and Fourier transform were calculated for each image in the database. All extracted shape parameters were entered in a stepwise linear discriminant analysis to extract the most important parameters that most characterized the regularity of potatoes.

In Grading and color evolution of apples using RGB and hyper spectral imaging vision cameras [5], segmentation, preprocessing and partial least squares-discriminant analysis (PLS-DA) were used for hyper spectral data analysis, while illumination correction, dimensionality reduction and linear discriminant analysis (LDA) were used for RGB data analysis.

Support vector machine approach to real-time inspection of biscuits on moving conveyor belt [6], discuss the state-of-the-art classification techniques based on Support Vector Machines (SVM) and Wilk's λ analysis were used to classify biscuits into one of four distinct groups: under-baked, moderately baked, over-baked and substantially over-baked. The accuracy of the system was compared with standard discriminant analysis using both direct and multi-step classifications. It was discovered that the radial basis SVM after Wilk's λ was more precise in classification compared to other classifiers. Real-time implementation was achieved by means of multi-core processor with advanced multiple-buffering and multithreading algorithms.

An image processing method for in-line nectarine variety verification based on the comparison of skin feature histogram vectors [7], presents an image processing method for in-line automatic and individual nectarine variety verification in a fruit-packing line based on the use of feature histogram vectors obtained by concatenating the histograms computed from different color layers of a circular central area of the skin of the nectarines processed. The verification procedure requires the definition of a small dataset with the feature histogram vectors corresponding to some reference nectarines (manually selected) whose skin clearly identifies the variety being processed. The in-line variety verification of each nectarine processed is then done by computing and comparing its current feature histogram vector with the reference dataset.

Identification of grapevine varieties using leaf spectroscopy and partial least squares [10], reports the development of a simple and automatic method of classification of grapevine varieties from leaf spectroscopy. The method consists of a classifier based on partial least squares that discriminate among grapevine varieties using a hyperspectral image of a leaf measured in reflectance mode. Hyperspectral imaging was conducted with a camera with 1040 wavelength bands operating between 380 nm and 1028 nm. The classifier was created using 300 leaves, 100 of each of the varieties Vitis vinifera L., Tempranillo, Grenache and Cabernet Sauvignon. Monte-Carlo cross-validation confirmed the classifier's performance for the three varieties, which exceeded 92% in all cases. The proposed method has proven to satisfactory classify among grape varieties, but certainly a wider range of grapevine cultivars should be tested before it gets implemented for local sensing with the aim of providing the wine industry with a fast, automatic, environmentally friendly and accurate tool for grapevine variety identification.

Application of hyperspectral imaging technology different geographical origins of Jatropha curcas [12], obtains seed samples from four different geographical origins (Jiangsu, Sichuan, Hainan and Taiwan) in China were studied and all of them were scanned by a push broom hyperspectral imaging system. Then obtained data sets were analyzed by spectral and image processing technique respectively. Successive projections algorithm (SPA) was used for selecting effective wavelengths. Dimension reduction was carried out on the region of interest (ROI) image by principal component analysis (PCA).

All the above discussed approaches have the problem of false classification rate and less accurate grading [14].

Multi Level Intensity Estimation Based Fruit Grading: The Proposed multi level intensity estimation technique has different functional methods namely Preprocessing, Segmentation, Feature Extraction, Rule Generation, Multi Attribute Fruit Grading. We will explain each of the functional component in detail in this section.

Preprocessing: The preprocessing is the process of improving the image quality, which will be used in most efficient manner in the other stages of fruit grading. The input image is applied with gabor filter which removes the noisy values present in the image. The noise removed image is applied with histogram equalization technique which increases the image quality and the contrast. The enhanced image is used to support the segmentation process.

Algorithm:
Input: Image Img.
Output: Preprocessed Image Pimg

Step 1: Start
Step 2: Apply gabor filter to the image Img.
Img = GaborFilter(Img).
Step 3: Initialize all possible intensity values.

$$\text{Ivset} = \sum_{i=1}^{size(Intensity)} Intensity(i)$$

Step 4: for each intensity value IVi
Perform Histogram Equalization.
end
Step 5: Stop.

The Figure 1, shows the architecture of the proposed system and it shows the functional components of the proposed system.

Segmentation: In this stage, the method performs background subtraction from the image. The enhanced image is read and from the enhanced image there will be background objects present in the image. The method identifies the objects present in the background and removes the background from the image. The background subtracted image will be used to perform feature extraction. By performing the background subtraction, the Region of interest is identified and will be used to perform feature extraction.

Feature Extraction: In the feature extraction stage, the method extracts the shape of the object present in the image. The presence of object is identified by performing the edge detection and the method identifies the co-ordinates of the object present in the image. Identified shape features is converted into template. Then from the input image, we extract the intensity features of all of the pixels present in the image. The method generates the histogram of intensity values which represents the feature vector of the input image.

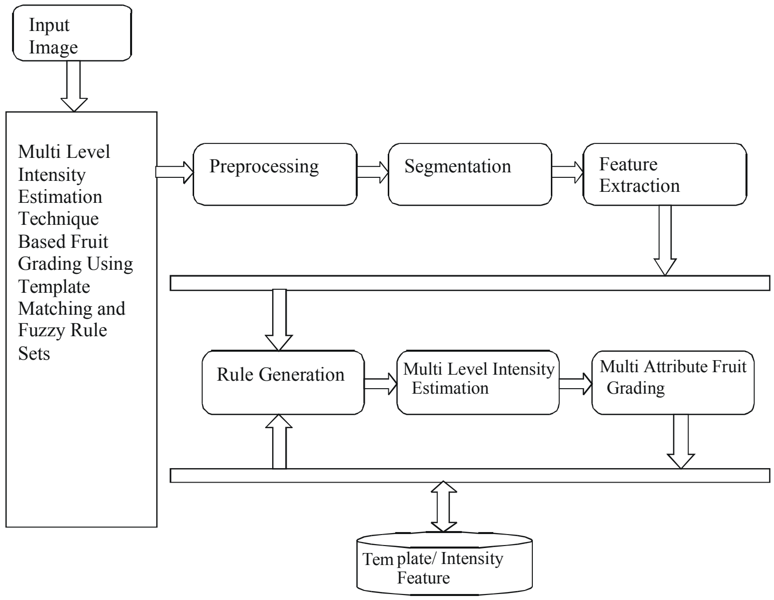


Fig. 1: Proposed System Architecture

Input: Segmented Image SImg
Output: Feature Vector Fv.

Step 1: Start
Step 2: Perform edge detection by canny edge detector.
Step 3: Collect the co-ordinates of the edge points

$$EC = \sum_{i=1}^{size(img)} Pixels \in Boundary$$

Step 4: Construct template Temp.

Shape Template ST = EC.

Step 5: Compute histogram of image Hist.

$$Hist = \sum_{i=1}^{Possibleintensity} Pixel(i) \in Intensity$$

Step 6: Construct Feature Vector FV= {Template, Hist}.
Step 7: Stop.

Rule Generation: The rule generation is performed using the feature being extracted from number of training samples. For each input image, from the extracted shape feature, we compute the volumetric measure of the shape being extracted. For each class considered, from the all the template available in the class, we compute the range value of volumetric measure to construct the rule. Similarly the rule has the range values for each possible intensity of the color image. The generated rules will be used to compute the multi attribute multi level intensity estimation and compute the multi attribute fruit grading.

Algorithm:
Input: Feature vector FV.
Output: Rule set Rs.

Step 1: Start
Step 2: For each class Cl
for each feature vector Fvi
Compute volumetric measure Vm = $Area(\Sigma Points(Fvi)$
end
Compute range value for the shape feature.
Shape Range SR = Min(Vm)U Max(Vm).
for each feature vector Fvi
for each possible intensity
Compute Mean value of intensity Min.

$$Min = \sum_{i=1}^{size(Int)} \frac{Number\ of\ pixel\ with\ intensity\ Int(i)}{Total\ Number\ of\ pixels}$$

end.
Generate Rule Ri = {SR,R(I1),R(I2)…..R(In)}.
Add rule to the rule set.
End
Step 3: Stop.

Multi Level Intensity Estimation: The multi level intensity estimation is performed with the feature vector given and the feature vectors present in the each classes training set. For each feature vector present in different classes we compute the multi level intensity estimation. The MLIE is computed at different intensity range values present in the feature vectors of different classes. We compute the intensity similarity at different levels which decides the class of feature vector to which it belongs.

Algorithm:
Input: Feature Vector FV, Rule Set Ts.
Output: MLIE set.

Step 1: Start
Step 2: for each class Cl from the Classes
Compute multi level intensity estimation MLIE.
MLIE = $\sum_{i=1}^{size(FV \in Cl)} \frac{\Sigma FV \in Ts}{size\ of\ features\ vectors}$
end

Step 3: Stop.

Multi Attribute Fruit Grading: The multi attribute fruit grading approach performs the grading of the fruit using various functional components. For each class available in the training set, we compute the volumetric similarity measure and compute the multi level intensity estimation. The volumetric similarity decides the class to which the fruid belongs and the multi level intensity estimation decides the grade of the fruit. Using both the values the grade of the fruit is identified.

Algorithm:
Input: Feature vector Fv, Rule set Rs.
Output: Fruit Grade FR.

Step 1: Start
Step 2: For each class
Compute the volumetric similarity Vsim = $\sum_{i=1}^{size(Fv)} \Sigma volume\ (RS) \in Volume(Fv)$
end

Step 3: Choose the most Volumetric similarity class.
Step 4: For each class of the fruit
Compute Multi Level intensity estimation MLIE.
MLIE = $\sum_{i=1}^{size(RS)} \Sigma Intensity(FV) \in Intensity(RS)$
end

Step 5: Choose the level or class which has more intensity measure.
Step 6: Stop.

RESULTS AND DISCUSSION

The proposed multi level intensity estimation technique with fuzzy rule sets has been implemented and tested for its efficiency. The results shows clearly that the proposed method has produced efficient results than other methods. The method has produced efficient results in classification and fruit grading and reduces the time complexity also.

The Table 1, shows the details of evaluation parameters used to evaluate the efficiency of the proposed method.

The Figure 2, shows the snapshot of fruit grading result produced by the proposed method and it shows that the input image is alphonsa and its grade is I.

The Figure 3, shows the snapshot of fruit grading result produced by the proposed method and it shows that the input image is senthura and its grade is I.

The Figure 4, shows the snapshot of fruit grading result produced by the proposed method and it shows that the input image is senthura and its grade is III.

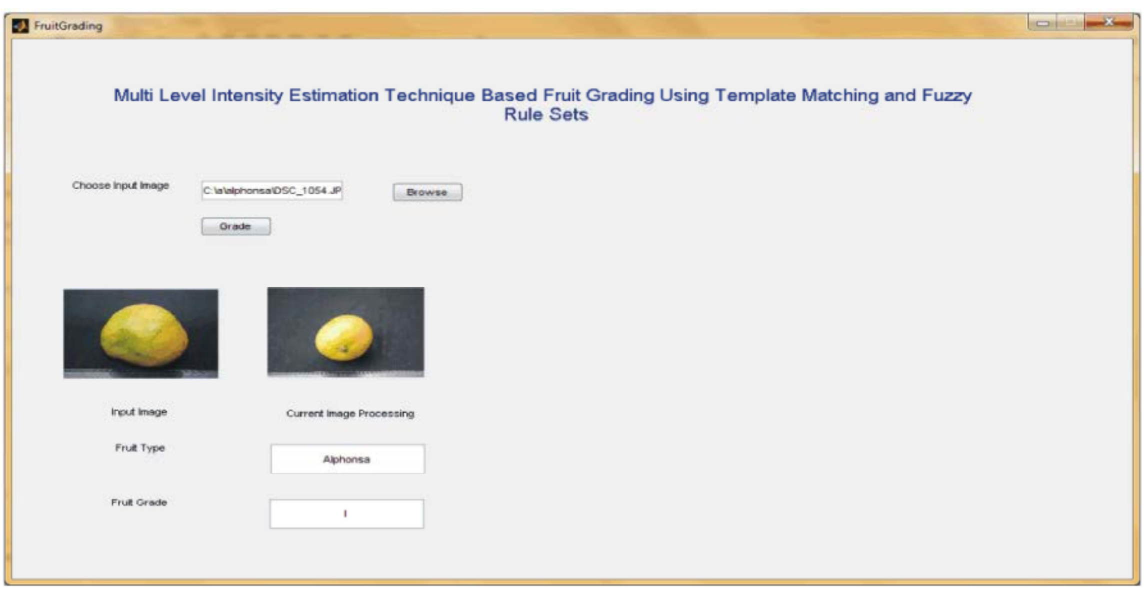


Fig. 2: Snapshot of Multi Level Intensity Based Fruit Grading

Table 1: Details of evaluation parameters

Parameter	Value
Number of Fruits	100
Average Number of class of fruits	10
Number of samples of each class	500
Number of rules	10,000

Table 2: Comparison of results based on training/testing samples

Size of Training and Testing samples	Classification Rate	False Classification Rate	Accuracy
70 by 30	96.5	2.3	97.8
80 by 20	97.6	1.8	98.9
90 by 10	98.7	0.7	99.6

Table 3: Comparative results on number of classes

Number of classes	False Classification Rate	Accuracy
5	0.4	99.7
10	0.5	99.6
15	0.6	99.5

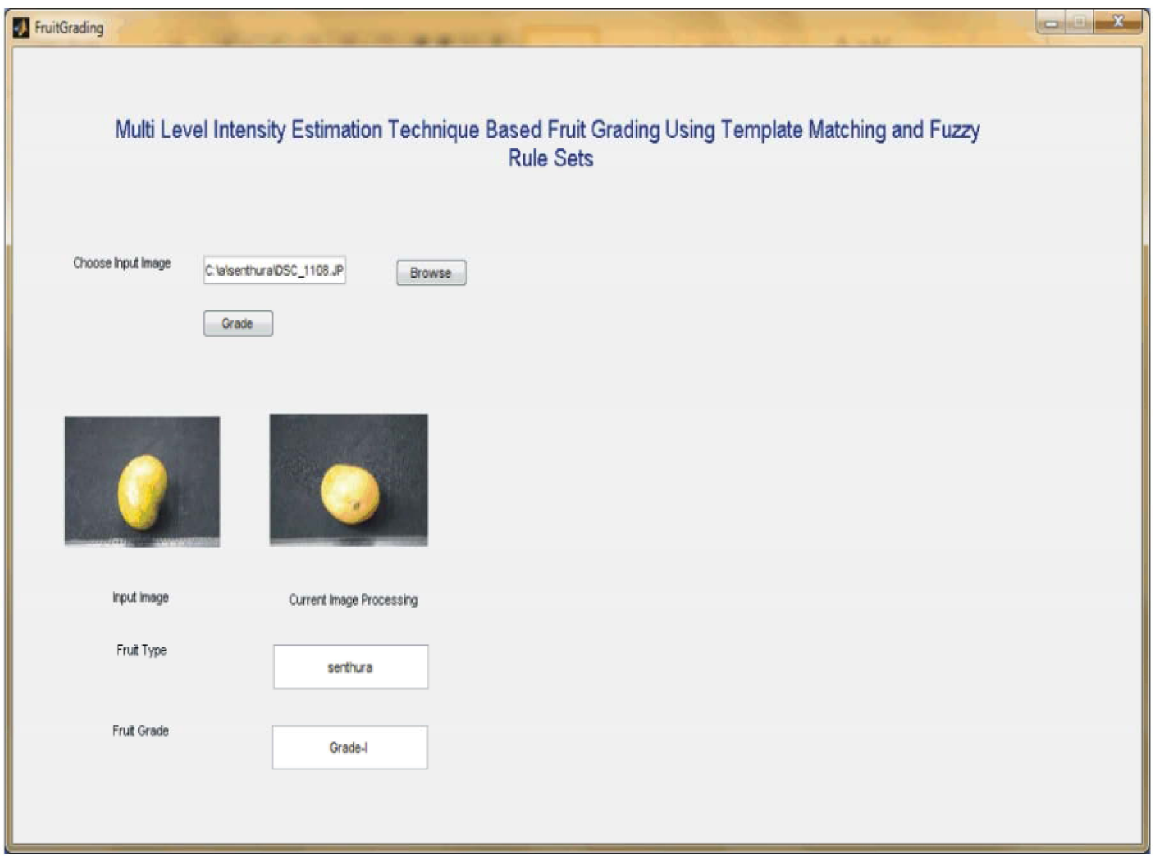


Fig. 3: Snapshot of Multi Level Intensity Based Fruit Grading

The Graph 1, shows the comparative analysis of different methods on grading accuracy and it shows clearly that the proposed method has produced efficient results in grading accuracy.

The Graph 2, shows the comparative results of false classification ratio produced by different methods and it shows clearly that the proposed method has produced less false classification ratio than other methods.

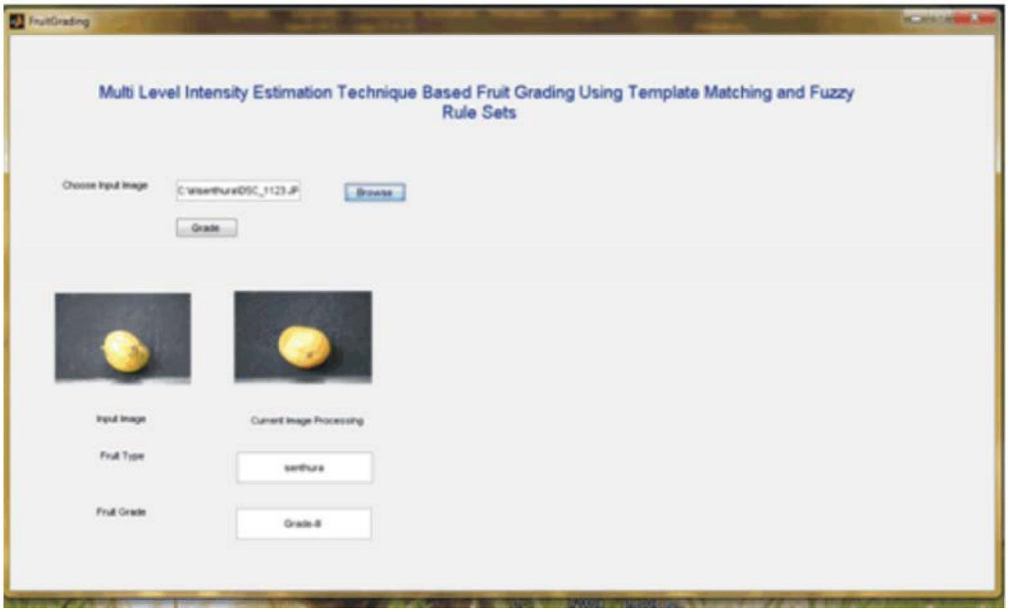
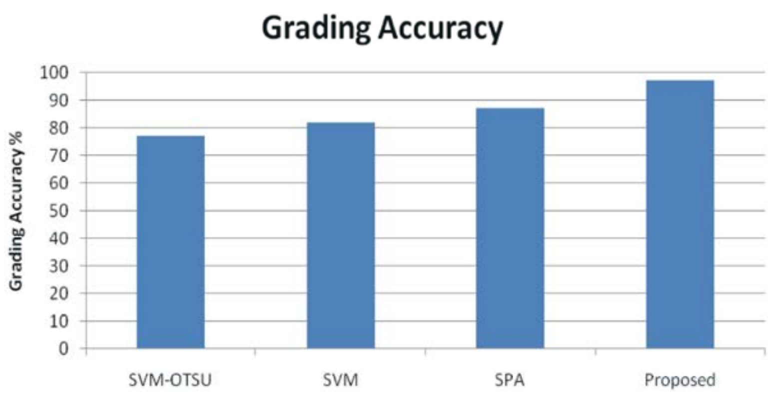
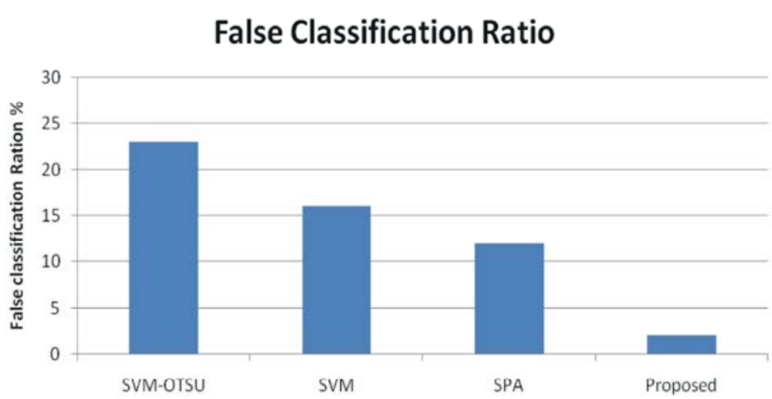


Fig. 4: Snapshot of Multi Level Intensity Based Fruit Grading



Graph 1: Comparison of grading accuracy of different methods



Graph 2: Comparison of false classification ratio

The Table 2, shows the comparative analysis of results produced by the proposed method on different size of training and testing samples. The method has been analyzed for its classification rate, false classification rate and accuracy. The results show that the proposed method has produced efficient classification results.

The Table 3 shows the comparative results produced by proposed method based on number of classes used. The results show that the proposed method has produced efficient results in all the number of classes.

CONCLUSION

To solve the problem of fruit grading, we proposed a novel multi level intensity estimation technique using the template matching and fuzzy rule sets. The method preprocesses the input image to remove the noise by applying the gab or filter and enhances the image by applying histogram equalization technique. Improved quality image is segmented to remove the background object and the object shape is identified by applying the edge detection and boundary detection process. The method also computes the intensity estimation and generates the feature vector using the shape feature and intensity features. Using all these feature vectors, the method generates the rule set and based on this the method computes the multi level intensity estimation and volumetric feature to compute the multi attribute fruit grading measure. Based on computed multi level intensity similarity and volumetric similarity, the grading of the fruit is assigned. The proposed method has produced efficient results in fruit grading and increases the accuracy of the fruit grading and reduces the time complexity also.

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