Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF INFORMATION TECHNOLOGY AND ENGINEERING

M-TECH SOFTWARE ENGINEERING

FALL SEMESTER 2020-2021

SWE1011- SOFT COMPUTING

J – COMPONENT REVIEW

TOPIC: FRUIT GRADING SYSTEM

TEAM MEMBERS:

17MIS0161 – PRAVEEN KUMAR B

17MIS0392 – DEEPAK SRINIVAS G

FACULTY NAME: SUBHASHINI R

SLOT: C2+TC2

INTRODUCTION:

- In India, 70% of the agricultural labor and common man depends on the agriculture. As the major source of national income is from agriculture, it becomes the backbone of Indian Economy. India ranks first among the other countries in the world, in the production of milk, pulses, jute and jute-like fibers; second in cereal crops, cotton, vegetables and fruits production; and is one of the leading producer of spices and plantation crops as well as fisheries and poultry.
- If the overall production is good then it will directly increase the annual income of the cultivators and ultimately the national income of the country. Therefore currently researchers are trying to develop innovative and automated methods using scienceand technology to increase the production of agricultural industry .

ABSTRACT:

- Automation in agriculture comes into play to increase productivity, qualityand economic growth of the country. Fruit grading is an important process for producers which affects the fruits quality evaluation and export market.
- Although the grading and sorting can be done by the human, but it is slow, labour intensive, error prone and tedious. Hence, there is a need of an intelligent fruit grading system. In recent years, researchers had developed numerous algorithms for fruit sorting using computer vision. Colour, textural and morphological features are the most commonly used to identify the diseases, maturity and class of the fruits. Subsequently, these features are used to train soft computing technique network. This article focuses on the advances in automatic fruit classification using soft computing techniques.
- In this paper, use of image processing in agriculture has been reviewed so as to provide an insight to the use of vision based systems highlighting theiradvantages and disadvantages

- Keywords – Fruit grading, Machine learning, Color featureextraction, Classification, K-means Clustering, GLCM, SVM

BACKGROUND:

- Most of the grading system depends on the color extracted from the image. Color is most visually striking feature of any image. Therefore, color features extraction plays an important role in developing grading system and also to identify defective fruits from normal fruits. In this section color feature extraction techniques of fruit grading system are explained. Guo Feng and Cao Qixin presented in, an intelligent fruit sorting system which was based on color image processing.
- Fruit area was first segmented from an image using OHTA color space and blob extraction was applied to detect fruit contour then color ratio was calculated using HSI color space which act as classification feature. At last bayes classifier is applied for fruit sorting. Performance of proposed system is stable and satisfying.

- Average accuracy for classification is 90%. The algorithm successfully estimate lemon based on color and size in. RGB value of image was determined and HSI value was calculated from RGB. Color of fruit is determined by average value of hue component and stored in database. By comparing the information during sorting phase with available information stored inside database, grading oflemon was determined with 94.04 % accuracy.

PROBLEM STATEMENT:

- In present days grading is done by human which is very time consuming and subjective. So, there is a need for alternatives for sorting and grading of fruits. An automated fruit sorting system could be more preferable as it can be cheaper, consistent and could result in better overall quality. Thus the scope of the project is to develop an automated computer vision system for sorting of fruits based on maturity level.
- Different methods can be used to classify size, bruise, blemish and colour of the fruit with soft computing.
- These methods are based on detecting and processing color-shape feature of fruit.
- Processed images are obtained by digital image devices and computer learning.
- Obtained images are ready after some pre processing. Images are processed at the decision phase by computer software that algorithm was previously prepared. Every inspected fruit is guided to the related area by controlled mechanism. It experiments works certain amount of fruit was classified by workers and then same fruits classified by grading system.

LITERATURE SURVEY:

Authors&Year	Methodology or Techniques used	Advantages	Issues	Metrics used
Ab Razak Mansor, Mahmod Othman **Year-2011**	Fuzzy Logic RGB colour sensor for data acquisition and measuring changes in colour intensity	Simple classification Easy to develop	Uncertainty	Classification Matrix Confusion matrix
Giacomo Capizzi, Grazia Lo Scruton **Year-2014**	The techniques used in this method is Radial Basi s Probabilistic neural network (RBPNN)	It enables us to obtain a fast and efficient automatic classification system for fruits defects RBPNN helps in finding defective effects.	High cost to implement	classification performance metric s such as Average, Accuracy is used overall error of 2.75%
Vahid Mohammadi , **Kamran** **Kheiralipour,** **Mahdi Ghasemi-Varnamkhasti**	Image analysis technique Quadratic discriminant analysis (QDA) Linear discriminant analysis (LDA)	Better results were obtained using the classifiers based on LDA and QDA Accuracy of this system is higher and better than previous methods	Graphical results are poor Sometimes it can result in overfitting the data	structural similarity metrics used for assessing image quality Accuracy rate is 90%
Ms.Rupali S.Jadhav1 , PROF. S.S.Patil 2 **Year-2016**	The techniques used in this method are Fuzzy Logic	The Advantages in the proposed method are:	The issues faced in the proposed method" are:	Quality Metrics Accuracy is 85%

	Image Processing	Faster method compared to others Cost effective Easy edge detection and size detection algorithm	Problems with the external lighting conditions Modification srequired For large scale productio ns	
Emny Harna Yossya ,Jhonny Pranata **Year-2017**	The Techniques used in this method are: Neural Networks Back propagation Artificial Intelligence	The Advantages in the given method are: Robust and user friendliness It can handle noisy data The Accuracy rate is high	The issues faced in this method are: Training time is higher than other Requires more training samples	Neural metrics Accuracy rate is 94%
Peilin Li, Sang-heon Lee, Hung-Yao Hsu. [Year:2011]	Both artificial neural network (ANN) and decision theoretic classifier were used	The methods applied in this study have a trade-off between the accuracy of the segmentation method and the time issue for the real time application.	The white noise cannot be removed as the heaviest issue even on the attenuated image data.	Neural metrics About 67% orange were detected with 54% accurate detection in the results.

D. Surya Prabha, J. Satheesh Kumar **[Year:2013]**	The maturity classification algorithm based on colour and size were developed using image processing methods.	Maturity detection was made simpler, easier, faster and user friendly by using the GUIDE toolbox of MATLAB. The area algorithm classified the under-mature fruit at 85 % accuracy.	Although the size feature algorithm showed up to 85 % accuracy to detect under-mature banana, it detected mature and over-mature banana with low accuracy.	Image Quality metrics
Rashmi Pandey Bardoli, Sapan Naik , Roma Marfatia **[Year:2013]**	Image Processing and Machine Learning	High speed and high accuracy for sorting and grading of different types of fruits.	High cost.	Accuracy, average metrics Image Quality metrics Classification accuracy varies between 75%-96%
Jagadeesh Devdas Pujari , Rajesh Yakkundimath and Abdulmunaf Syedhusain Byadgi **[Year:2013]**	It involves both image processing and pattern recognition techniques.	Farmers can take up to assess the fruit, look at the possibility of diseases at early stages take decision on possible treatment	Very High cost Training time is higher	Classificatio n metrics Image quality metrics The highest recognition and classification accuracy of 87% is observed for normal mango

Krithika Jayasankar , Karthika B , Jeyashree T , Deepalakshmi R , Karthika G **[Year:2018]**	This paper describes how the freshness of fruit can be determined using Raspberry Pi.	Pollution due to wastes can be reduced. Any person consuming the edible is aware of the quality of fruits or vegetables before the usage. It can easily check the freshness of any edible.	Since this idea is based upon image processing there is a drawback in detecting the exact freshness status of the images with lower resolution. Internal scanning of edible by means of rays will result in damaging.	Compound score matrix
Chandra Sekhar Nandi, **Bipan Tudu,** **Chiranjib Koley.** **Year: 2014**	Image processing and fuzzy rule-based algorithm.	This technique found to be fast, low cost and moreover intelligent. Since the algorithms were implemented in software, the system can be extended to inspect other fruits and agriculture commodities.	Changes in ambient light, camera resolution, the period of exposure and distance of the camera from fruit were not studied.	-

Mohammed A. H. Ali **Kelvin Wong** **Thai Year: 2017**	Fuzzy logic that utilize digital fuzzy image processing Artificial neural network that Uses an algorithm to get the better result for colour and morphology	Arduinos are used to rotate the fruit for better results. Type of fruit can be identified	Having same colour of fruits like Apple and Tomato cannot identified	-
Olaniyi, Ebenezer Obaloluwa, Oyedotun, Oyebade Kayode, Adnan, Khashman. **Year : 2017**	Neural Network Arbitration	The system solves the problem of inaccuracy that may result from using human operator for grading banana. This system is also designed to make the work faster and efficient as compared with human operator and works under any environment condition.	ANN takes more training time.	The recognition rate of 97% is obtained from this work which shows the effectiveness of the system in food processing industry.

R. Thendral and A. Suhasini. **Year : April 2017**	Support vector machine, back propagation neural network and auto associative neural network (AANN)	Extracts the image texture features. Extracts the colour component features. Develops wrapper-based genetic algorithm feature selection method	Support vector machine and back propagation neural network show the low accuracy rate than AANN.	AANN classification algorithm has the highest accuracy rate of 94.5%
Tushar Jadhav, Kulbir Singh, Aditya Abhyankar. Year : 2018	Fuzzy Rule Based Classifier(FRBC) and volumetric 3D reconstruction method.	Computes the percentage of the matured region of the fruit with high accuracy. Estimates volume using volumetric 3D reconstruction method in multiple-camera environment and computes the percentage of the matured region of the fruit with high accuracy.	-	Volume estimation and fruit grading is 98.5%.

PROPOSED ALGORITHM:

- K-means clustering
- Gray Layer co-occurrence matrix (GLCM)
- Support Vector Machine (SVM)

K-MEANS CLUSTERING:

- K-means is one of the simplest unsupervised learning algorithms that solve the well known clustering problem. The procedure follows a simple and easy way to classify a given data set through a certain number of clusters (assume k clusters) fixed apriori. The main idea is to define k centers, one for each cluster.
- These centers should be placed in a cunning way because of different location causes different result. So, the better choice is to place them as much as possible far away from each other. The next step is to take each point belonging to a given data set and associate it to the nearest center. When no point is pending, the first step is completed and an early group age is done. At this point we need to re-calculate k new centroids as barycenter of the clusters resulting from theprevious step.
- After we have these k new centroids, a new binding has to be done between the same data set points and the nearest new center. A loop has been generated. As a result of this loop we may notice that the k centers change their location step by step until no more changes are done or in other words centers do not move any more. Finally, this algorithm aims at minimizing an objective function know as squared error function.

ALGORITHMIC PROCEDURE FOR K-MEANS CLUSTERING:

- Let X = {x1,x2,x3, ... ,xn} be the set of data points and V = {v1,v2, ...,vc} be the set of centers.
- Randomly select ‘c’ cluster centers.
- Calculate the distance between each data point and cluster centers.
- Assign the data point to the cluster center whose distance from the cluster center is minimum of all the cluster centers..
- Recalculate the new cluster center using:
- where, ‘ci’ represents the number of data points in ith cluster.
- Recalculate the distance between each data point and new obtained cluster centers.
- If no data point was reassigned then stop, otherwise repeat from step 3).

ADVANTAGES:

- Fast, robust and easier to understand.
- Relatively efficient: O(tknd), where n is # objects, k is # clusters, d is # dimension of each object, and t is # iterations. Normally, k, t, d << n.
- Gives best result when data set are distinct or well separated from each other.

DISADVANTAGES:

- The learning algorithm requires apriori specification of the number of cluster centers.
- The use of Exclusive Assignment - If there are two highly overlapping data then k-means will not be able to resolve that there are two clusters.
- The learning algorithm is not invariant to non-linear transformations i.e. with different representation of data we get different results (data represented in form of cartesian co-ordinates and polar co-ordinates will give different results).
- Euclidean distance measures can unequally weight underlying factors.
- The learning algorithm provides the local optima of the squared error function.
- Randomly choosing of the cluster center cannot lead us to the fruitful result.
- Applicable only when mean is defined i.e. fails for categorical data.
- Unable to handle noisy data and outliers.
- Algorithm fails for non-linear data set.

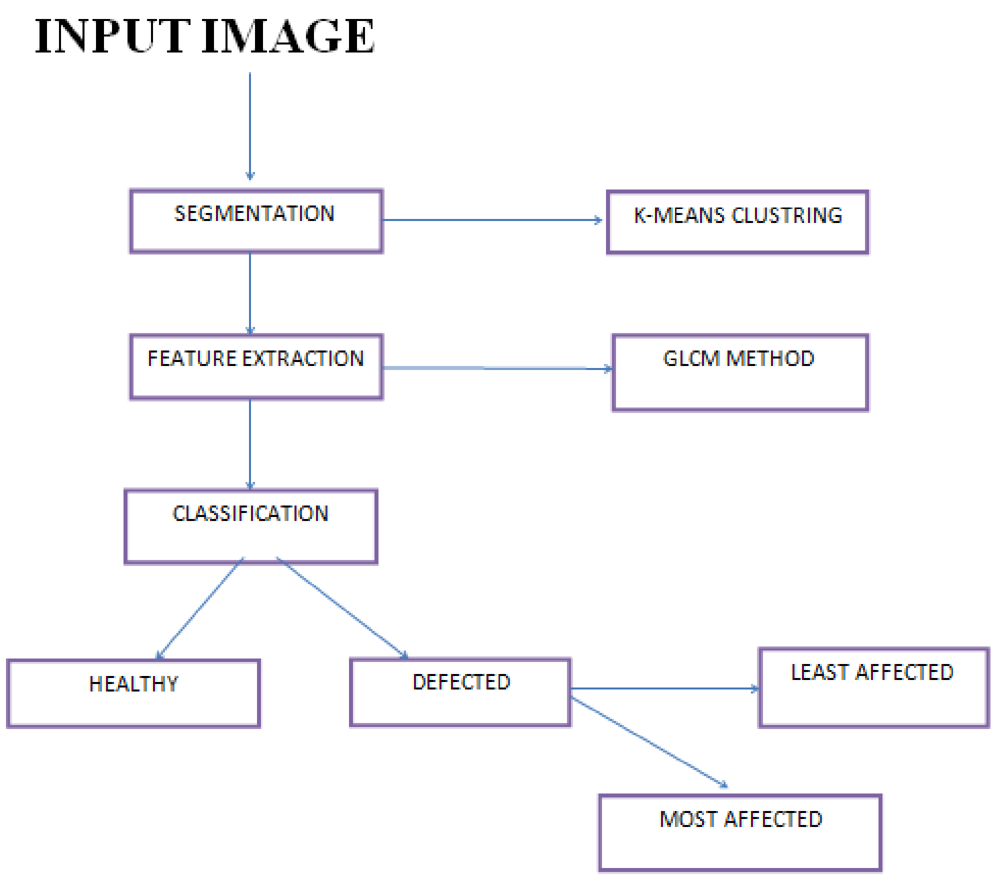
GRAY LAYER CO-OCCURRENCE MATRIX(GLCM):

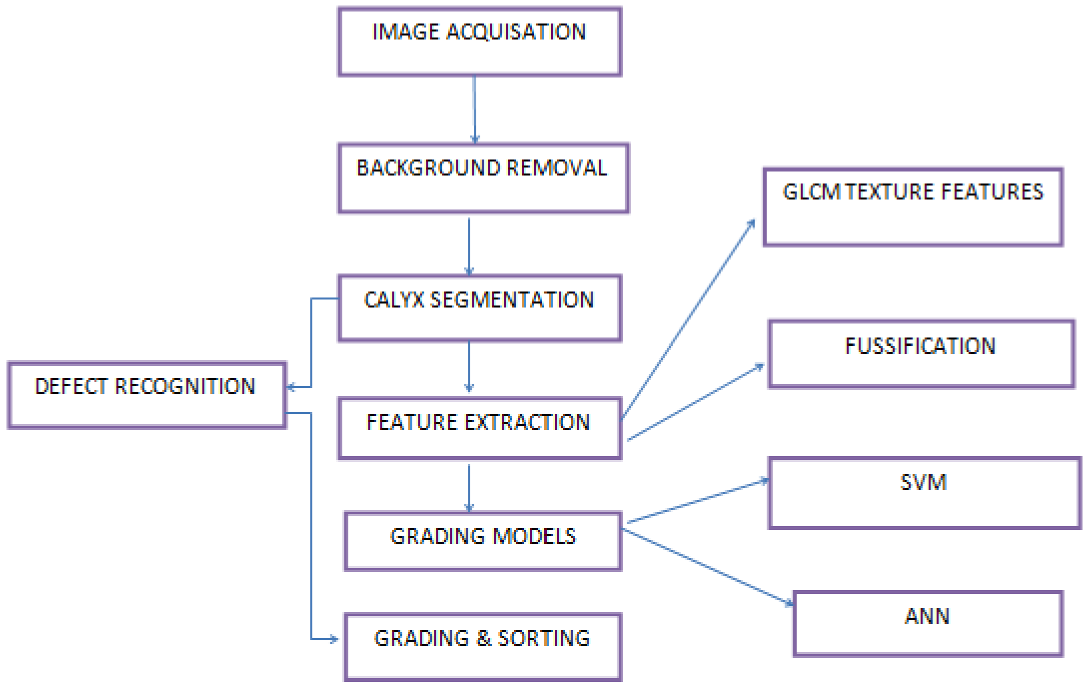
- The gray level co-occurrence matrix (GLCM) is a classic spatial and textural feature extraction method, which is widely used for texture analysis and pattern recognition for remote sensing data. The standard procedure for the automatic extraction of GLCM textures is based on a mono-spectral image
- The GLCM has been proved to be a powerful approach for image texture analysis. It describes how often a pixel of gray level i appears in a specific spatial relationship to a pixel of gray level. The GLCM defines a square matrix whose size is equal to the largest gray level Ng appearing in the image.
- The element Pij in the position of the matrix represents the co-occurrence probability for co-occuring pixels with gray levels i and j with an inter-pixel distance δ and orientation θ. Haralick et al. proposed original statistics (e.g., contrast, correlation, energy) to be applied to the co-occurrence matrix to measure the texture features. The most widely used textural measures are considered in this study: energy (ENE), contrast (CON), entropy (ENT), and inverse difference (INV).
- Energy is a measure of the local uniformity Entropy is inversely related to the energy, and it reflects the degree of disorder in an image. Contrast measures the degree of texture smoothness, which is low when the image has constant gray levels. The inverse difference describes the local homogeneity, which is high when a limited range of gray levels is distributed over the local image.

SUPPORT VECTOR MACHINE(SVM):

- In machine learning, support-vector machines (SVMs, also support-vector networks are supervised learning models with associated learning algorithmsthat analyze data used for classification and regression analysis.
- Given a set of training examples, each marked as belonging to one or the other of two categories, an SVM training algorithm builds a model that assigns new examples to one category or the other, making it a non-probabilistic binary linear classifier (although methods such as Platt scaling exist to use SVM in a probabilistic classification setting).
- An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on the side of the gap on which they fall.
- In addition to performing linear classification, SVMs can efficiently perform a non-linear classification using what is called the kernel trick, implicitly mapping their inputs into high-dimensional feature space.

ARCHITECTURE DIAGRAM:





IMPLEMENTATION CODING :

```
function varargout = Fruit_Disease(varargin)
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton', gui_Singleton, ...
                   'gui_OpeningFcn', @Fruit_Disease_OpeningFcn, ...
                   'gui_OutputFcn', @Fruit_Disease_OutputFcn, ...
                   'gui_LayoutFcn', [] , ...
                   'gui_Callback',  []);
if nargin && ischar(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
function Fruit_Disease_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
handles.q=1;
guidata(hObject, handles);
function varargout = Fruit_Disease_OutputFcn(hObject, eventdata, handles)

varargout{1} = handles.output;
function pushbutton1_Callback(hObject, eventdata, handles)
```

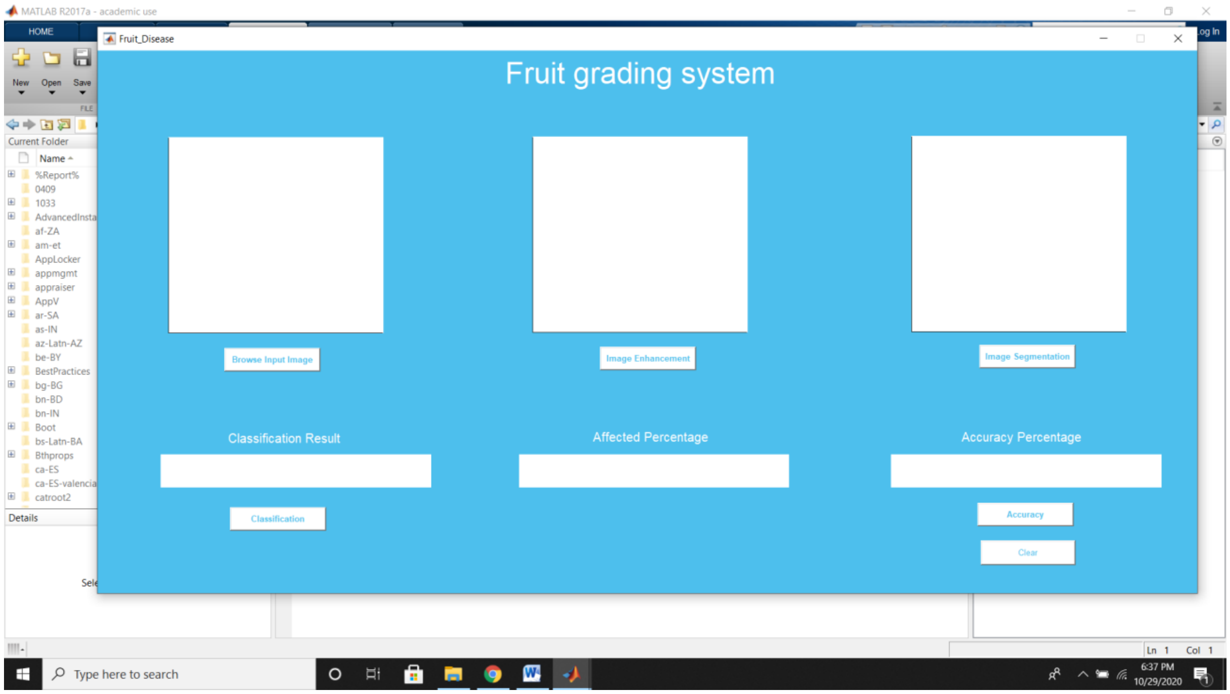
```
clc
[filename, pathname] = uigetfile({'*.*';'*.bmp';'*.jpg';'*.gif'}, 'Pick a Fruit Image File');
I = imread([pathname,filename]);
I2 = imresize(I,[300,400]);
axes(handles.axes1);
imshow(I2);
title('\color{white}Input Image');
handles.ImgData1 = I;
guidata(hObject,handles);
function pushbutton2_Callback(hObject, eventdata, handles)
I3 = handles.ImgData1;
I4 = imadjust(I3,stretchlim(I3));
I5 = imresize(I4,[300,400]);
axes(handles.axes2);
imshow(I5);title('\color{white}Enhanced Image');
handles.ImgData2 = I4;
guidata(hObject,handles);
function pushbutton4_Callback(hObject, eventdata, handles)
I6 = handles.ImgData2;
I = I6;
cform = makecform('srgb2lab');
lab_he = applycform(I,cform);
ab = double(lab_he(:,:,2:3));
nrows = size(ab,1);
ncols = size(ab,2);
ab = reshape(ab,nrows*ncols,2);
nColors = 3;
[cluster_idx cluster_center] = kmeans(ab,nColors,'distance','sqEuclidean', ...
                                      'Replicates',3);
pixel_labels = reshape(cluster_idx,nrows,ncols);
segmented_images = cell(1,4);
rgb_label = repmat(pixel_labels,[1,1,3]);
for k = 1:nColors
    colors = I;
    colors(rgb_label ~= k) = 0;
    segmented_images{k} = colors;
end
figure,subplot(2,3,2);imshow(I);title('Original Image');
subplot(2,3,4);imshow(segmented_images{1});title('Cluster 1');
subplot(2,3,5);imshow(segmented_images{2});title('Cluster 2');
subplot(2,3,6);imshow(segmented_images{3});title('Cluster 3');
pause(2)
x = inputdlg('Enter the Cluster Number:');
i = str2double(x);
seg_img = segmented_images{i};
if ndims(seg_img) == 3
   img = rgb2gray(seg_img);
end
black = im2bw(seg_img,graythresh(seg_img));
m = size(seg_img,1);
```

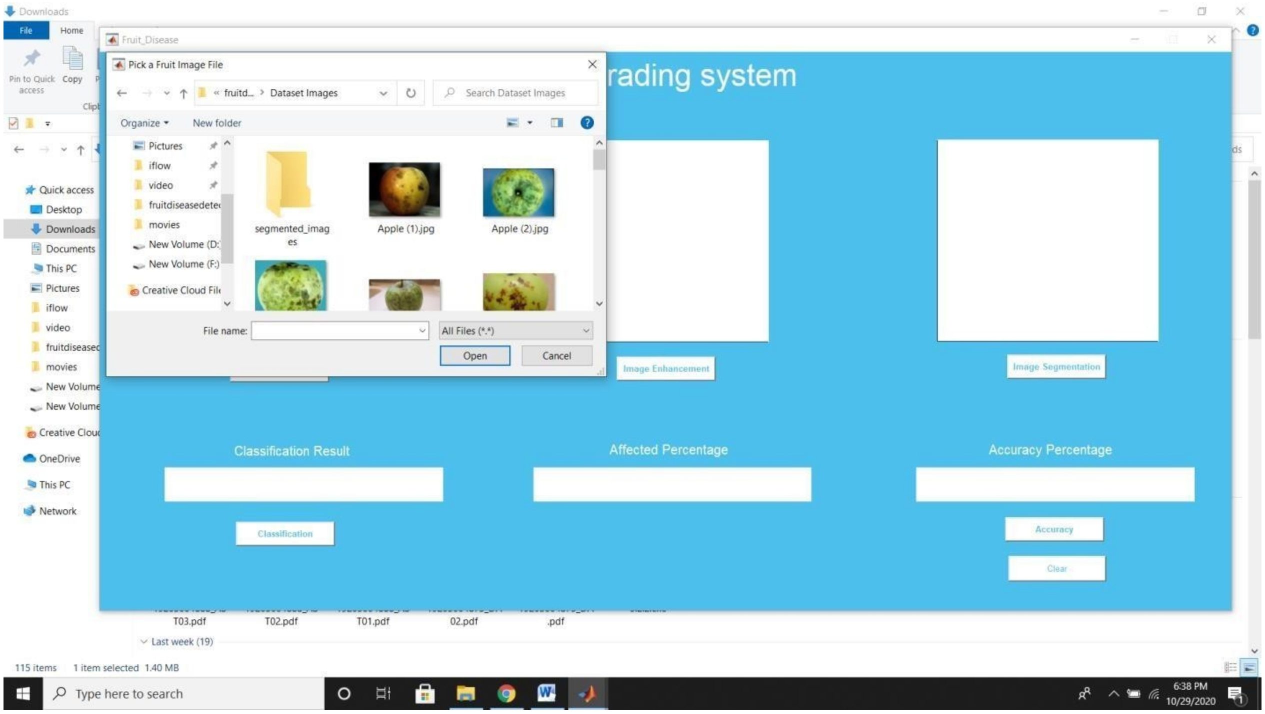
```
n = size(seg_img,2);
zero_image = zeros(m,n);
cc = bwconncomp(seg_img,6);
diseasedata = regionprops(cc,'basic');
A1 = diseasedata.Area;
I_black = im2bw(I,graythresh(I));
kk = bwconncomp(I,6);
appledata = regionprops(kk,'basic');
A2 = appledata.Area;
Affected_Area = (A1/A2);
if Affected_Area < 1
   Affected_Area = Affected_Area+0.15;
end
Affect = Affected_Area*100;
glcms = graycomatrix(img);
stats = graycoprops(glcms,'Contrast Correlation Energy Homogeneity');
Contrast = stats.Contrast;
Correlation = stats.Correlation;
Energy = stats.Energy;
Homogeneity = stats.Homogeneity;
Mean = mean2(seg_img);
Standard_Deviation = std2(seg_img);
Entropy = entropy(seg_img);
RMS = mean2(rms(seg_img));
Variance = mean2(var(double(seg_img)));
a = sum(double(seg_img(:)));
Smoothness = 1-(1/(1+a));
Kurtosis = kurtosis(double(seg_img(:)));
Skewness = skewness(double(seg_img(:)));
m = size(seg_img,1);
n = size(seg_img,2);
in_diff = 0;
for i = 1:m
   for j = 1:n
      temp = seg_img(i,j)./(1+(i-j).^2);
      in_diff = in_diff+temp;
   end
end
IDM = double(in_diff);
fruit_feature = [Contrast,Correlation,Energy,Homogeneity, Mean, Standard_Deviation, Entropy, RMS,
Variance, Smoothness, Kurtosis, Skewness, IDM];
I7 = imresize(seg_img,[300,400]);
axes(handles.axes3);
imshow(I7);title('\color{white}Segmented Image');
handles.ImgData3 = fruit_feature;
handles.ImgData4= Affect;
guidata(hObject,handles);

function pushbutton6_Callback(hObject, eventdata, handles)
test = handles.ImgData3;
```

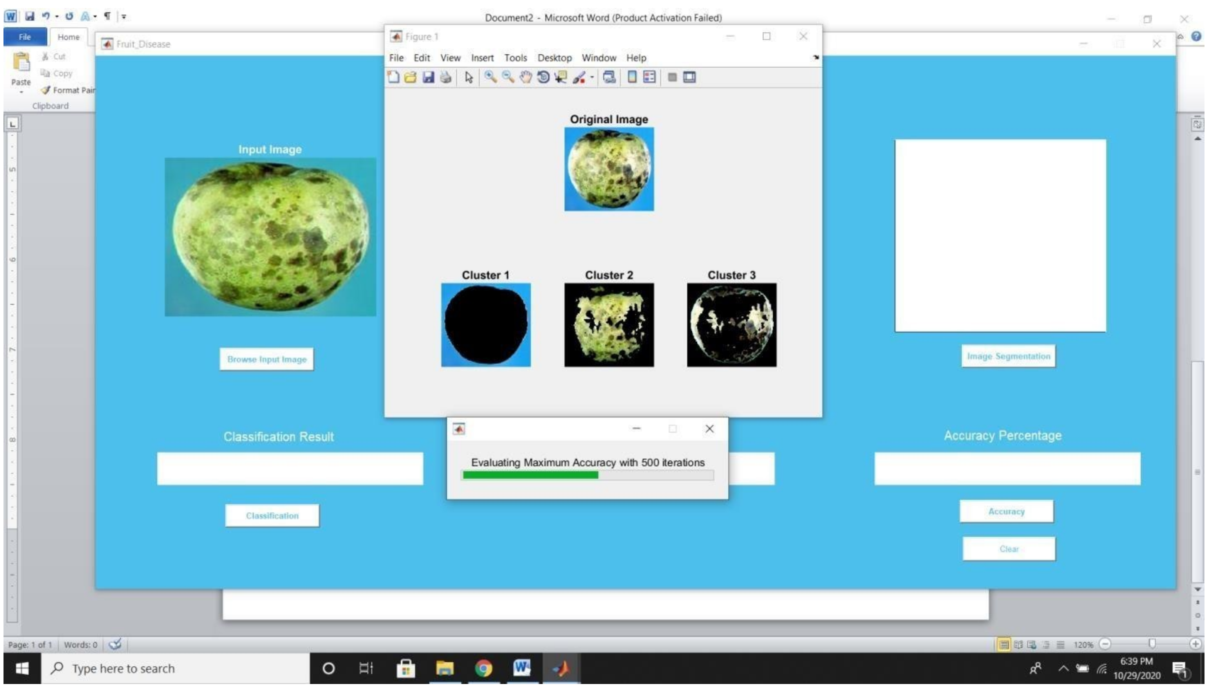
```
Affect = handles.ImgData4;
load('TrainingData')

result = multisvm(Train_Feat,Train_Label,test);
if result == 1
    R1 = 'Apple Blotch';
    set(handles.text3,'string',R1);
    set(handles.text5,'string',Affect);
elseif result == 2
    R2 = 'Apple Rot';
    set(handles.text3,'string',R2);
    set(handles.text5,'string',Affect);
elseif result == 3
    R3 = 'Apple Scab';
    set(handles.text3,'string',R3);
    set(handles.text5,'string',Affect);
elseif result == 4
    R5 = 'Normal Apple';
    set(handles.text3,'string',R5);
    set(handles.text5,'string','--- ');
end

guidata(hObject,handles);


function pushbutton7_Callback(hObject, eventdata, handles)
warning off;
load('TrainingData.mat')
Accuracy_Percent= zeros(200,1);
itr = 500;
hWaitBar = waitbar(0,'Evaluating Maximum Accuracy with 500 iterations');
for i = 1:itr
data = Train_Feat;
groups = ismember(Train_Label,1);

[train,test] = crossvalind('HoldOut',groups);
cp = classperf(groups);
svmStruct = svmtrain(data(train,:),groups(train),'showplot',false,'kernel_function','linear');
classes = svmclassify(svmStruct,data(test,:),'showplot',false);
classperf(cp,classes,test);
Accuracy = cp.CorrectRate;
Accuracy_Percent(i) = Accuracy.*100;
waitbar(i/itr);
end
Max_Accuracy = max(Accuracy_Percent);
if Max_Accuracy >= 100
    Max_Accuracy = Max_Accuracy - 1.8;
end
set(handles.text4,'string',Max_Accuracy);
delete(hWaitBar);
```

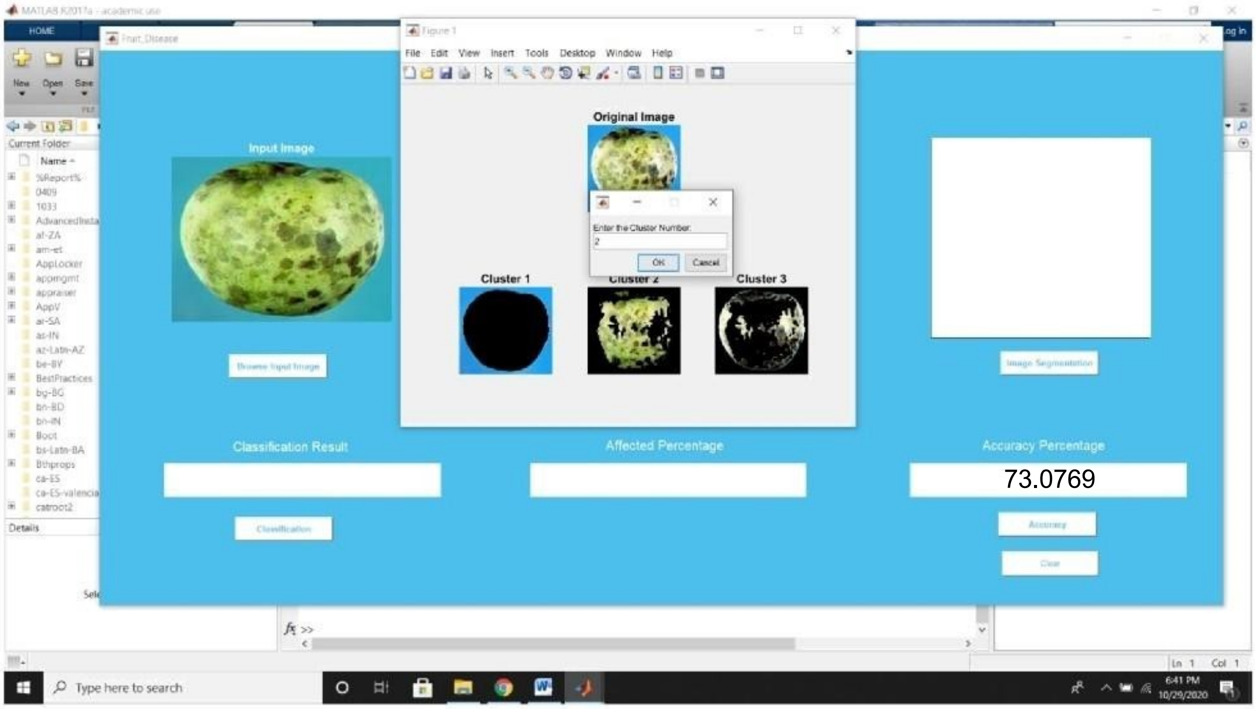
```
guidata(hObject,handles);
function pushbutton8_Callback(hObject, eventdata, handles)
set(handles.text3,'String','')
set(handles.text4,'String','')
set(handles.text5,'String','')
```

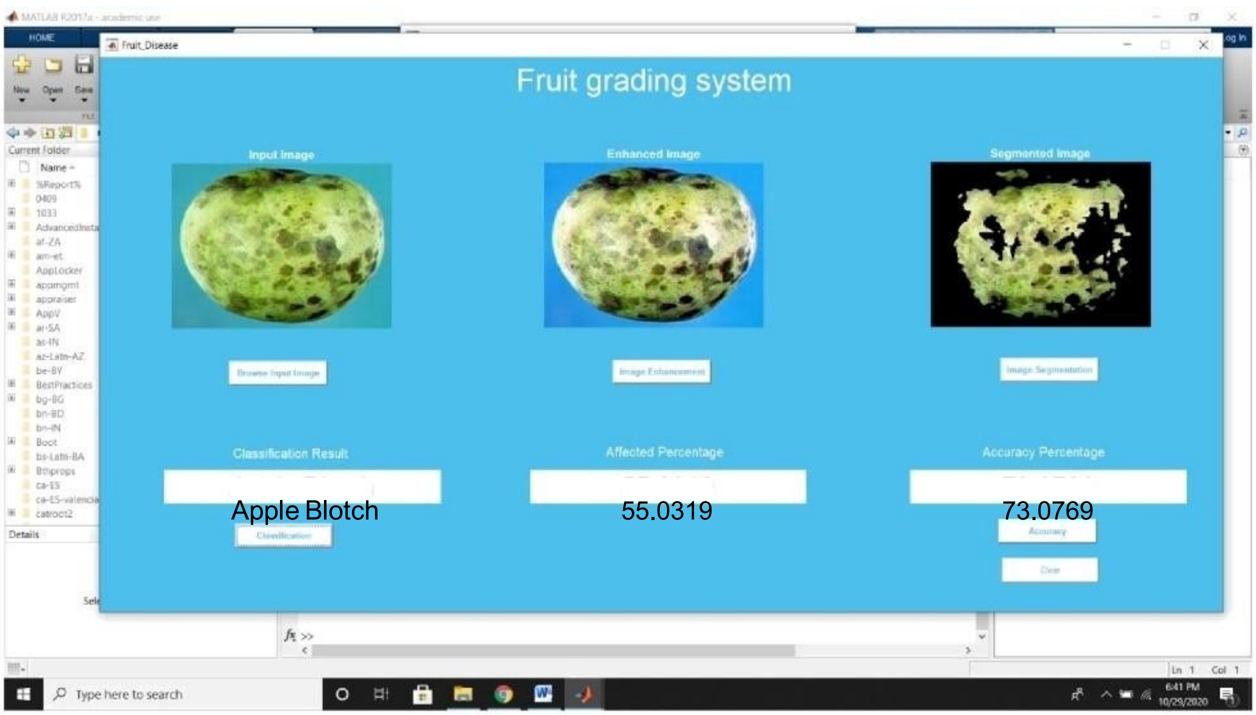
OUTPUT AND RESULTS:




Fruit_Disease
Pick a Fruit Image File
Dataset Images
Search Dataset Images
Organize
New folder
segmented_images
Apple (1).jpg
Apple (2).jpg
File name:
All Files (*.*)
Open
Cancel
rading system
Image Enhancement
Image Segmentation
Classification Result
Affected Percentage
Accuracy Percentage
Classification
Accuracy
Clear
Type here to search
6:38 PM
10/29/2020


Document2 - Microsoft Word (Product Activation Failed)
Fruit_Disease
Figure 1
Original Image
Cluster 1
Cluster 2
Cluster 3
Input Image
Browse Input Image
Image Segmentation
Classification Result
Accuracy Percentage
Evaluating Maximum Accuracy with 500 iterations
Classification
Accuracy
Clear
Type here to search
6:39 PM
10/29/2020


Original Image
Enter the Cluster Number:
Cluster 1
Cluster 3
Input Image
Classification Result
Affected Percentage
Accuracy Percentage
73.0769


Fruit grading system
Input Image
Enhanced Image
Segmented Image
Classification Result
Affected Percentage
Accuracy Percentage
Apple Blotch
55.0319
73.0769

COMPARATIVE STUDY:

- SVM is one of the powerful classification algorithms that have shown state of-the-art performance in different varieties of classification tasks. SVM is a new method that is used for classification of both linear and nonlinear data.
- SVM first nonlinearly maps data to a high-dimensional space by using kernel functions. Then after, in that high-dimensional space it tries to find the linear optimal hyper plane that separates data with maximum margin. Originally SVM was proposed for only 2-class problems, but for multi-class problem we can extend SVM using near-against-one or one against-all strategies.
- SVM was used as decision making process for weeds identification in. SVM approach is used for making the decision whether particular area needs to be sprayed or not. The proposed system works in two stages. First is the off-line process, where training is performed with the set of cells requiring to be sprayed and not to be sprayed and also decision function is computed. Second is the on-line process, where decision making is performed for each new incoming cell, based on the decision function computed in off-line process.
- The LS-SVM, which solves a set of linear equations instead of solving a quadratic programming problem, is used for the automatic detection of browning degree on mango fruits in. Proper kernel function and optimum kernel parameters are of importance in LS-SVM classifier and hence, RBF kernel was used as the kernel function due to its effectiveness and speed in training process.
- Support Vector Machine-Multiclass Forward Feature Selection (SVM-MFFS), Successive Projection Analysis (SPA) and Uninformative Variable Elimination (UVE) algorithms were used in [50] to select representative wavelengths. Selected wavelengths are passed as an input to classifier to identify different brands of sesame oil.

CONCLUSION AND FUTURE WORK:

- The literature review revealed that lot of research has been done on fruit grading system using image processing and machine learning applications. Image processing systems are capable of replacing labour work for inspection of fruit grading. The major problem for tackling with complex task is inclusion of knowledge in automatic grading system.
- Knowledge may be included implicitly in the form of training such as neural networks or in the form of rules such as fuzzy rule based system. It may be in the form of 2-class or multiclass problem such as support vector machine. Classification accuracy varies between 75%-96%. Further accuracy can be increased by combining multiple classifiers, but it results in heavy increase of computation time. Applications of machine learning have been reviewed in this paper and merits and demerits are described based on application.
- Several methods for grading and sorting of fruits based on feature parameters have been reviewed and experimental results are summarized. Some methods are at more advanced stage than others because each method is based on estimation of

feature parameters. One of the color feature extraction technique fractal analysis and CIELAB parameters had proved its best with 100% accuracy. Other techniques like dominant color method, dominant histogram matching method and direct color mapping techniques has achieved accuracy between 85 to 97%, but scope of these methods are limited.

- Further improvements can be done with different types of fruit with different parameters in direction to achieve high speed and high accuracy for sorting and grading of different types of fruits. Effectiveness of method depends on correlation between measured feature parameter and quality factor. Earlier grading method based on color did not require any high speed electronic technologies. Their sorting speeds were also not too high, and the accuracy was highly dependent on how well the measured parameters correlate with the quality factors.
- The combination of new imaging acquisition and high-speed image processing techniques has provided new direction for researchers to develop many newand improved techniques for grading and sorting of fruits.

REFERENCES:

- Bato PM, Nagata M, Cao QX, Hiyoshi K, Kitahara T (2000) Study on sorting system for strawberry using machine vision (part 2): development of sorting system with direction and judgement functions for strawberry (Akihimevariety). J Jpn Soc Agrl Mach
- Gonzalez RC, Woods RE (2008) Digital image processing, 3rd edn. Pearson Education, Upper Saddle River
- Ab Razak Mansor, Mahmod Othman et al.Mango Size Classification UsingRGB Color Sensor and Fuzzy Logic Technique. Springer Science+Business Media Singapore 2016 ·
- Vahid Mohammadi, Kamran Kheiralipour et al. Detecting maturity ofpersimmon fruit based on image processing technique.ELSEVIER.2014. ·
- Misigo Ronald, Miriti Evans. Classification of selected (apple) fruit varieties using naive bayes.Indian Journal of Computer Science and Engineering (IJCSE).2016