Volume: 5 **Issue:** X **Month of publication:** October 2017

DOI: http://doi.org/10.22214/ijraset.2017.10135

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue X, October 2017- Available at www.ijraset.com

Various Techniques Used In Defect Segmentation and Disease Inspection in Fruits and Vegetables: A Survey

Nikhil Pandey[1], Suraj Kumar[2], Raksha Pandey[3]
[1,2]Department of CSE, School of Studies in Engg.& Tech.
[3]Assistant Professor, Department of CSE ,School of Studies in Engg. & Tech.
GuruGhasidasVishwavidyalaya,Bilaspur,(c.g.),INDIA

Abstract-Computer vision and machine learning are two young and promising technology. Paired together they have been in use for inspection, identification, object recognition and many more. Agricultural markets suffer heavily due to the loss caused by diseases. It can be easily prevented if only the farmers and cold storage owners knew what exactly the disease the product is suffering from. With the increasing reach of smartphone, digital cameras have been getting available to the masses. We are aiming to develop algorithms that can detect and estimate the diseases in vegetables and fruits. Such algorithms can be accommodated in smartphones and can potentially change the way the current inspection of the agricultural produces. Here we have tried to identify the key algorithms from recent work that could help us developing more advanced algorithms.

Keywords: Computer Vision, Machine Learning, SVM, CNN, Deep Learning, Thresholding, K-means clustering, Fruits, Vegetables.

I. I. INTRODUCTION

India has an estimated 6500 cold-storages having total capacity around 30.1 million tones. As Indian economy depends heavily on Agriculture based produce, any major loss in production or to the produce becomes a dent in GDP. According to data of 2016, there was a loss of 12 Billion USD that year as post-harvest loss. This is a massive blow to the developing economy. Also, to be noted that 75-80% of the cold storages are used to store potatoes even though the crop share of potato is around 20% of the total. Plant diseases are cause of 26% loss in yield.

With the advent of technology, it is possible to use state of the art algorithms to detect and classify diseases. Object recognition and spatial analysis can be done more efficiently with higher accuracy with the development of Deep Learning and other techniques. With APIs like TensorFlow, OpenCV, SkLearn, SkImageetc, it has become possible to quickly devise a robust and accurate algorithm for any desired purpose.

II.TECHNIQUES

A. *Defect Segmentation Techniques*

As the name suggests, Image segmentation is the process of dividing an image into different segments [1]. It is performed in order to simplify the data so that we can analyze it efficiently.. It can be viewed as label assigning process to each individual pixel in an image.

1) *Automated Skin Defect Identification System for Fruit Grading Based on Discrete CurveletTransform*Khoje et al[2] has used curvelet transformation to analyze the defects in guava and lemon. Texture measurement based on curvelet transformation such as energy, entropy, mean and standard deviation were used to characterize the surface texture of the fruites. The extracted data that is generated from the curvelet transformation can be subjected to statistical analysis so that it can reveal any statistical patterns. Dimensionality reduction is required to generate meaningful feature set so that the focus of the algorithm is only on the most relevant data features.Mean, contrast, energy, correlation,sum-mean, standard deviation, cluster tendency etc. are some of the major statistical features which are used to do the data analysis. The approach is straightforward, get the data from curvelet transformation and provide it as input to the classifiers.Khoje et al[2] used two primary classifier, SVM and Neural Network of which they report that SVM yields better results. The radial Basis kernel of the SVM classifier gives an accuracy of

91.42% and 95% for classifying Guava and Lemon. It is to be noted that neural networks would require large amount of non-linear data whereas SVMs works well even with moderate amount of data.

2) *Automatic detection of skin defects in citrus fruits using a multivariate image analysis approach:* This is not anstand alone computer vision algorithm. Rather it is a data analysis technique combined with non-conventional image analysis.Multivariate images consists of spatial, intensity or spectral resolution. Physical units can be used to make images and multivariate images. Temperature, impedance, magnetic field, ultrasound wavelength, electrical field, mass, wavelength, electron energy, polarization etc variables can be used to make an image multivariate [3].When images become multivariate, domains other than image itself become significant too..They were able to gain an accuracy of 91.5% in defect detection while the classification ratio of damaged/sound sample was 94.2%.
3) *An image segmentation approach for fruit defect detection using k-means clustering and graph-based algorithm:* Image processing using clustering is an efficient method. The object of clustering algorithms is to classifies the objects into different groups so that the data in each group has some common properties. The computational task of partitioning the data set into k subsets is often referred to unsupervised learning algorithm K-means Clustering.Segmentation of Images using K-means clustering is an useful method in Image analysis. An important aspect of image segmentation is to separate the object from the background also referred to as foreground and background extraction. The proposed method is reportedly superior to Otsu's method in the terms of continuous contour and better quality which could increase the adaptivity to general purpose use. Similar approach is used in Dubey et al [4] in which they have used K-Means Clustering for Infected Fruit part detection successfully. They have presented a segmentation procedure which is based on using color features of the images by using the K-means clustering algorithm.The segmentation process is divided in two parts, first each image pixel is clustered using their color which is achieved by using clustering as described earlier. Next the pixels are combined to a fixed number of regions which are decided by the factors which vary from image to image. They argue that the use of this two stage process is computationally efficient in extracting features from images. They also justify the use of color by saying that it provides power to differentiate different regions of images. The result of their experiments very clearly show that the proposed algorithm improves segmentation quality and the required time for computation.
4) *A real-time mathematical computer method for potato inspection using machine vision:* Thresholding on binary images have been proved helpful to detection and measurement of anomalies. Razamjooy et al [5] uses an RGB color space with contrast enhancement. The method proposed in their paper consists of two steps. Initially mathematical binarization is applied to sort the object on the basis of their size. After that color based classifier are introduced to segment the image .Binarization is performed to remove background. After extracting the region of interest, it is very easy to find the spatial properties like shape, size etc. For Defect detection, they have used similar classifiers as we have seen before however they have emphasized on the use of popular technique such as MLP(Multi-layer perceptron) and SVM. SVM seems to be the king of all the algorithms in computer vision and machine learning. VaniAshok et al[6] have used the method of Binary Thresholding to preprocess the Apple images before giving it to the classifier. They developed a model to classify defected apples from good ones. They chose global threshold segmentation in YCbCr color space to perform Binary thresholding and Segmentation over the Apple images. The choice of YCbCr color space is justified because it provides abetter segmentation rather than others by clearly distinguishing fruits from background colors.
5) *Image Segmentation for Fruit Detection and Yield Estimation in Apple Orchards:* Bargoti et al [7] uses this machine learning technique to train the object detector using apple images dataset which contains apple images of different variety. They have used this model to effectively count the number of Apples in an Image and thereby estimating the Apple's yield.The classifier they made takes as input a contextual window around individual pixels from the raw RGB image, with the windows sampled at different image scales. The data is propagated through multiple fully connected layers and the output of the classifier is a probability of a given pixel belonging to the class fruit/non-fruit. A three layered Multi-layer perceptron architecture is used as the classifier. The image patchesare initially forward propagated into the first hidden layer using non-linear sigmoid transformations. The sigmoid function is then used to merge all the outputs of the activation links by minimising a cross-entropy loss function, parameters are tuned via supervised learning. Overfitting is addressed by using L2 minimization penalty. Apart from using MLP Bargoti et al [7] have used CNNs as well for detecting and counting the number of Apples in the Image. CNNs are feed forward neural networks, which combine and merge several different types of forward propagating layers, with convolutional layers playing an important role. Like the MLP, the network computes the probability of a pixel being a fruit or non-fruit, using as input the image intensities of a square window centred on the pixel itself. However, instead of using small multi-scale patches, CNNs can take as input larger/high resolution patches covering the same contextual region. CNNs have the

ability to share smaller scale filters in each layer thereby minimizing the number of model parameters. The patch based Convolutional Neural Network architecture with 2 convolutional + pooling layers and 2 fully connected layers. Each pixel is defined by a large contextual region around it (48×48 color pixels) and is propagated through the CNN. Metadata are appended to the fully connected layer.

Approach	Description	Limitations
Clustering	Clustering algorithms like k-means are used to segment the images. K-means is an unsupervised learning algorithm which classify the pixels into different classes which in turn segment the entire image. Fairly easy and quicker way to segment.	Not much independence of parameter tuning as k-means takes the number of means beforehand . X-means is more evolved form of k-means which address this issue.
Edge Based methods	Group of methods which are based boundaries or edges. Different operators are used to find edges combined with supplementary processes whose main aim is to combine edges to get better borders in the image.	Not tolerant to noise. if we rescale the images, the results will vary. Very poor scaling with high dimensional images.
Colour based	Uneven skin colour tones in agricultural produce corresponds to defect and disease. Colour space such as L*a*b, YCrCb, BGR, RGB etc. are chosen appropriately as per the segmentation problem. A clustering algorithm like k-means can segment the image in into defected and healthy regions.	The quality of image and illumination variation are the limiting factors. Different results appear when the condition of image capture is varied. Scalability is issue as well.

Various segmentation approaches and their merits.

B. *Defect Classification Techniques*

1) *Potato leaf disease detection and classification system:* Athanikar et al [8]have described a detection procedure using neural networks to detect and classify leaf samples of potatoes. The most common unsupervised algorithm K-means clustering is used for segmentation in another algorithm for processing color images of potato leaf samples. The leaves used in their study is either diseased or healthy as seen by a human observer. The algorithm which they develop uses 24 features in total which were extracted from gray level co-occurence matrix. The classifier which they have used is based on a Backpropagation Neural Network which can classify whether the input leaf is diseased or healthy. It also provides a description of the detected disease if the leaf is classified as diseased. Their algorithm takes a color image as input and after resizing it to a standard size it is filtered using the Gaussian filter. The K-means clustering is effective in extracting the exact diseased part from the leaves. This extracted diseased part is then provided as input to the feature extractor which will extract meaningful features of the disease present in the input image based on color, area, texture. The features extracted from the previous stage is then stored in knowledge based system for future use. The neural network architecture that is most commonly used with the backpropagation algorithm is the multilayered feed forward network.
2) *A Review of Curvelets and Recent Applications :*upport vector machines with linear kernels have gained popularity since Dalal and Triggs[9]. Support vectors Machines is a supervised learning model which in association with learning algorithms can analyze the data that is typically associated with regression and classification problems. Combination of SVM with several algorithms can be found to be used for detection for defects in fruits and vegetables. Clustering algorithms paired up with SVM can be observed in the Segmentation Section. Razamjooy et al[5] has used SVM+K-means clustering to segment the defected parts in potatoes. In their attempt to classification of the defects in potato using Curvelettransformation[10], [2] has used SVM with radial kernel. Support Vector Machines provides us minimum margins between classes in multidimensional hyperplane which makes them very robust in classification tasks. SVMs are known for being more data efficient than Deep Learning which

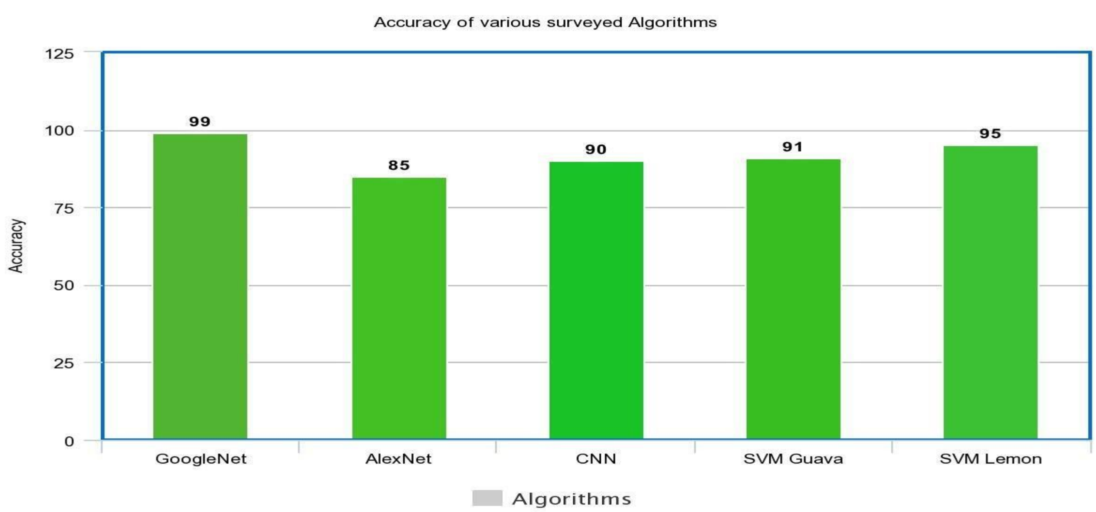
means they would require less training data as compared to Deep Learning. Cross Validation can simply give us the indication about overfitting in SVM classifier. We have compared SVM to ANNs and CNNs used by various people. There are several criteria of what one could consider a feature. Apart from obvious spatial properties i.e color, shape, volume et. there may exist other feature such as correlation, temperature, entropy etc that can be used to classify the defects in images of plant leafs, vegetables, fruits etc.

3) *Automatic fruit classification using random forest algorithm:* Zawba et al [11] have used the Random Forest algorithm to classify images of Apples, Oranges and Strawberries. They have used Scale Invariant Feature Transform (SIFT) on the raw images and classification of 178 image samples is done using Random Forest algorithm. In order to compare the performance of Random Forest Algorithm the same 178 images is provided as input to other machine learning models like SVM, K-Nearest Neighbour and their running time and accuracy is compared. The data is hand labelled and then divided into training and test set which comprises of 60% and 40 % data respectively.
4) *Using Deep Learning for Image-Based Plant Disease Detection:*Deep learning has tackled many mutually exclusive problems and has provided groundbreaking results. Deep learning involves numerous hidden layers in the typical architecture of ANN. Deep refers to the depth of the hidden layers. The input layers takes the image or any other form of non-linear data. The network of hidden layers then maps it to a class and adjust the weights of nodes via error correction methods like SGD or backpropagation making it an end-to-end algorithm. Deep Belief Networks, Recurrent Neural Network, Deep-CNN etc are few examples of Deep learning.AlexNet[15] and GoogleNet[12] are the two most popular choice of network architecture. AlexNet[11] follows the earlier version of LeNet[13] of 1989 while GoogLeNet[12] is quite a new one. They have achieved remarkable accuracy scores in their respective validations. The authors have been very careful about the choice of as the depth of the layers matters when it comes to overfitting. However, they have been careful about avoiding the overfitting. They have also used three different datasets: RGB, Gray scale and leaf Segmented. Their best train-test-split is 80-20.The overall accuracy is reported to be in the range of 85.53% to 99.34%. Color dataset experimentally proved to be superior over others. They have carefully tested and tuned each parameter. We would encourage the reader to have a look at JianxinWu[14] if they are new to classification using CNN.

Classifier	Description	Advantage	Disadvantage
Support Vector Machines	SVM classify the data using multi-dimensional hyperplane using appropriate kernels.	Defined by convex optimization problem, no local minima. Contains regularization parameter. Kernel based approach Takes less training data	Choosing appropriate kernel is tricky. Accuracy drops in case of discrete data. High memory requirement due to quadratic programming
Random Forest	This is an ensemble model which has many decision trees as constituents and the relative voting is used to classify the object	One most accurate learning algorithm. Runs efficiently on large datasets Large number of inputs can be given.	Susceptible to overfitting. Gradient boost is required to converge, may get stuck at local minima. Memory requirement can be massive.Dimensionality reduction is advised.
ANN	Artificial Neural Networks are supervised Learning Algorithms that uses back-propagation to minimise the error rate. They can also be viewed as parallel processors.	Relatively easy to use. Capable to approximate any function. Appropriate for abstract problems like image classification.	Requires very large amount of training data Acts as a Black Box, hence not much can be garner from it. Increasing the Accuracy by few percent can increase the complexity multiple folds.

CNN	Convolutional Neural Networks are one of the most popular DNN architectures which is appropriate for image classification. In some cases, it has resulted as high as 99% of accuracy with cross validation.	Advantage of having fewer weights to manage. Edges and other Gradients are often core of object recognition and with Pooling layers in CNN we can exclusively focus on that.	As the case in Artificial Neural nets, CNN too requires heavy training data. The optimal pooling layers varies with case. Takes large amount of time in training.
Deep Learning	Deep Neural Networks usually consist of more than one hidden layer. RNN, Deep Belief Network, Autoencoders are another example of deep learning.	Outperforms other solution on multiple domains. No need of feature engineering. Can easily adapt to new problems easily	Heavy amount of training data is required. Computationally Expensive Requires multiple GPUs Tuning of parameters is more of an art than science.

The model was heavily biased towards the lighting conditions and spatial arrangement of object. This problem can be addressed by using a more diverse dataset. This is quite simple approach which leads to satisfactory results.



IV.CONCLUSION

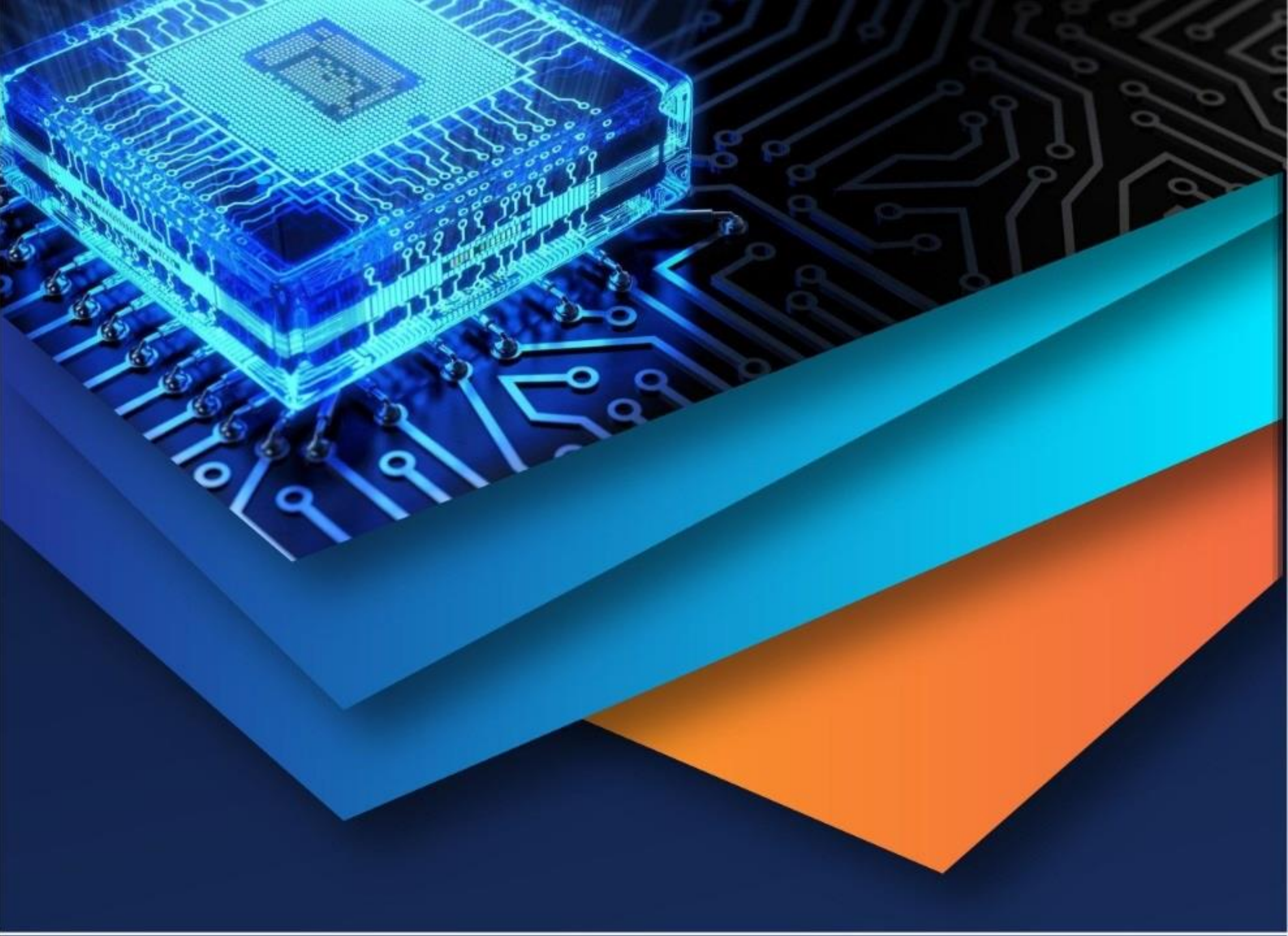
As we reviewed the algorithms, we noticed that they are getting simpler as the field of machine learning have been advancing . There are many non-destructive techniques possible to grade and sort vegetables and fruits. However, when combined with computer vision, machine learning is the future of inspection whether it comes to an agricultural produce or a spaceship. Feature descriptor such as curvelet transformation, edge based method, oriented gradient et. have been extensively and successfully used in past. As we have shown, classification is only as effective as segmentation. One must take care of segmentation process. Multiclass classification such as Deep Neural Network or multi-class SVM with different kernels have been used to classify the diseases and have proved effective under controlled condition. An observation that we have not mentioned yet: most of the algorithms whether computer vision or machine learning works with single input at a time. This would not be a problem if the systems that integrates them is designed for a processing unit of a company with a bit of infrastructure but they do have limitation when it comes to general purpose use of large cold storages.

V. FUTURE WORK

Techniques are still required which can process the objects in bulk. We are trying to devise an algorithm that could inspect potentially 400-500 objects (vegetables and fruits) on one go. However, the challenge remains of generating enough information from objects when their numbers are in hundreds in a single image which may range from typically 4MB to 8MB in size. We have had success in sorting and grading potatoes via CV and ML and we are currently working on the disease detection part.

REFERENCES

[1] Pedro F. Felzenszwalb, Daniel P. Huttenlocher "Efficient Graph-Based Image Segmentation"
[2] Suchitra A. Khoje, Dr S K Bodhe, DrAlpanaAdsul "Automated Skin Defect Identification System for Fruit Grading Based on Discrete Curvelet Transform" , International Journal of Engineering and Technology (IJET) 0975-4024.
[3] Barry M. Wise and Paul Geladi "A Brief Introduction to Multivariate Image Analysis (MIA)"
[4] Shiv Ram Dubey , Pushkar Dixit , Nishant Singh , Jay Prakash Gupta, "Infected Fruit Part Detection using K-Means Clustering Segmentation Technique" International Journal of Artificial Intelligence and Interactive Multimedia, Vol. 2, No 2. 10.9781/ijimai.2013.229.
[5] NavidRazmjooy, B.SomayehMousavi, F.Soleymani "A real-time mathematical computer method for potato inspection using machine vision" Computer and Mathematics with Application 63 (2012) 268 - 279.
[6] VaniAshok, Dr. D S Vinod "Automatic Quality Evaluation of Fruits Using Probabilistic Neural Network Approach", 2014 International Conference on Contemporary Computing and Informatics (IC3I), 978-1-4799-6629-5/14/$31.00 2014 IEEE
[7] SuchetBargoti, James P. Underwood "Image Segmentation for Fruit Detection and Yield Estimation in Apple Orchards", arXive: 1610.08120v1 [cs.RO].
[8] GirishAthanikar, PritiBadar "Potato leaf disease detection and classification system", International Journal of Computer Science and Mobile Computing,Vol.5 Issue.2,February,2016,pg. 76-88.
[9] Carlo Tomasi. International Conference on Computer Vision & Pattern Recognition (CVPR '05), Jun 2005, San Diego, United States. IEEE Computer So-ciety, 1, pp.886–893, 2005.
[10] Jianwei Ma, and GerlindPlonka "A Review of Curvelets and Recent Applications", IEEE Signal Processing Magazine 2009
[11] Hossam M. Zawbaa , Maryam Hazman , Mona Abbass , Aboul Ella Hassanien"Automatic fruit classification using random forest algorithm" 2014 International Conference on Hybrid Intelligent Systems (HIS) 978-1-4799-7633-1/14/$31.00 2014 IEEE
[12] GoogLeNet presentation.http://image-net.org/challenges/LSVRC/2014/slides/GoogLeNet.pptx
[13] LeNetY. LeCun, L. Bottou, Y. Bengio, and P. Haffner. "Gradient-based learning applied to document recognition" Proc. of the IEEE November 1998.
[14] Jianxin Wu et al Introduction to Convolutional Network
[15] Alex Krizhevsky and Sutskever, Ilya and Hinton, Geoffrey E, "ImageNet Classification with Deep Convolutional Neural Networks", Curran Associates, Inc. (2012) 1097--1105.



10.22214/IJRASET

45.98

IMPACT FACTOR:
7.129

IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY