INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 6.078
(Volume 6, Issue 2)
Available online at: www.ijariit.com

Fruit quality detection using machine vision techniques

S. Krishna Kumar
krishnakumar4699@gmail.com
Dr. Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu

J. Kaviya
jkaviya99@gmail.com
Dr. Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu

G. Dilip Prakash
dilipprakash@gmail.com
Dr. Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu

K. Srinivasan
srinivasank@drmcet.ac.in
Dr. Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu

ABSTRACT

Machine vision techniques are now widely used to detect the quality of fruits. Image processing is usually the first step in detecting the quality of fruits. The process starts by capturing the image of the fruits using raspberry pi. Then, the image is transmitted to the processing stage where it can extract the fruits features like shape, size and color. These processes are done using the image processing. It helps to identify and compare the fruit shape, size and color with the trained datasets. This is done during the training and testing stage. A diversity of methods for automatic separation of fruits is developed. Artificial Neural Network is the one that helps to segregate the fruits based on the quality such as good, moderate and rotten fruit. The existing system can only separate the fruits into good and rotten one with accuracy of 87.4% but our proposed system is capable of separating the fruits into good, moderate and rotten one with accuracy of 94.12%.

Keywords— *Machine Vision, Image Processing, Convolutional Neural Network, Fruits Quality Detection*

1. INTRODUCTION

In today's world, everything in agriculture is getting automated and manual interference in the system becomes non-commercial solution as well as time consuming task. The quality of fruit must be checked before it is used for making food products. In agriculture, the quality of fruit is somewhat dependent on the water availability, soil type, proper usage of fertilizers, etc. In old days, more manpower is required used for selection of quality fruits and vegetable for the production purpose in industries. In recent years many automated systems were invented and that are used for identification of quality fruits. The existing system finds the quality of fruits and display the message as good or rotten fruit which uses K-means algorithm of supervised learning technique, as it takes more time to predict the fruits quality with an average accuracy of 94.12%. Our proposed system is capable of finding the quality of fruit by using the classification algorithm of supervised learning technique in a short span of time with high accuracy. These features are used to classify the fruits into different categories like good, moderate and rotten fruits. Machine vision technique uses conventional neural network algorithm to predict whether the fruit quality is good, moderate or rotten.

The Convolutional Neural Network (CNN) is trained with good, moderate and rotten images of apple, orange and banana, so that it can predict whether it is good or rotten. Artificial neural network is the extension of many classification techniques. It classifies the fruits by using the shape, color and size features provided at the time of training and also the extracted features of fruit and provides the result by comparing these features. Finally, the fruits are categorized as a good, moderate and rotten one.

2. RELATED WORK

2.1 Literature Survey

2.1.1 Fruit Quality Inspection using Image Processing: The image processing circumvents the problem of processing or quantifying the photographic data mathematically. Several applications of image processing technology have been developed for the agricultural operations. These applications involve implementation of camera-based hardware systems or color scanners for inputting the images. Fruit classification and fruit disease identification can be seen as an instance of image categorization.

2.1.2 Image processing and machine learning for automated fruit grading system: ANN was used to classify empire and golden delicious apples based on surface characteristics of the apple images Textural and histogram features are extracted from the images at selected wavelengths. Then, images of apples with surface characteristics were used in classification applications with two cases two class classification and five class classification. Effectiveness of method depend on the correlation between measured feature parameter and quality factor.

2.1.3 Image Segmentation using K mean algorithm and Graph based algorithm: The algorithm firstly uses k-means algorithm to split the original image into regions based on Euclidean color distance in l*a*b* to produce an over segmentation result. The objective of this work is to develop a general algorithm to effectively segment objects in images to facilitate fruit defect detection. The dimension of feature vectors depends on the numbers of color channel used gray-level based k-means for segmenting images. L*a*b* or CIE-Lab color space is used for k-means clustering.

2.1.4 Fruit Classification System using Computer Vision: Color, textural and morphological feature are the most commonly used to identify the disease, maturity and class of the fruits. The computer vision technique include clustering and color based segmentation, artificial neural network and different classifiers based classification of disease. Using digital method, the disease detection can be accurately, time efficient and result in saves time. Different image processing techniques have been developed with help of MATLAB for accurate fruit disease identification.

2.1.5 Machine Vision Based Autonomous Fruit Inspection and Sorting: Machine vision technology or image processing is used for inspection and grade wise sorting of fruits. MATLAB algorithms like conversion to binary image, area calculation and average pixel value is used. Arduino-Uno microcontroller is used for sorting. HSV color space is used to carry out fruit segmentation. It captures the image of the fruit and calculate percentage value of the color in order to classify the grade of the fruit.

2.1.6 A Fruit Quality Management System Based on Image Processing: Fruit non-destructive detection is the process of detecting fruits inside and outside quality without any damage. CMOS based camera is used for capturing the image. Fruit color is detected according RCB values and fruits are sorted according to color and size. The image can be processed by using MATLAB software. The canny method differs from the other edge detection methods in that it uses two different thresholds to detect strong and weak edges in the output only if they are connected to strong edge.

2.1.7 Development of ANN Based Efficient Fruit Recognition Technique: Artificial neural network classifies the fruit by comparing shape, color and size provided at the time of training. MATLAB/SIMULINK software used to obtain the result. l*a*b technique is used for color detection in fruits. Calculate RGB parameters and then converted into hue. Color feature extraction algorithm is used to extract the color feature of the image. Convert a RGB image into HIS, HSV, l*a*b and YbCbCr.

3. METHODOLOGY

3.1 Machine Vision Technique

It provides image based automatic inspection and analysis for applications like automatic inspection, process control and robot guidance. The process includes planning the details of the requirements and project, and then creating a solution. During a run- time, the process starts with imaging followed by automated analysis of the image and extraction of required information.

Machine Vision technology that combines mechanics, optical instrumentation, electromagnetic sensing, digital video and image processing technology. As an integrated mechanical-optical-electronic-software system, machine vision has been widely used for examining, monitoring and controlling a very broad range of applications. It is the use of device for optical, non-contact sensing to automatically receive and interrupt the image of a real sense in order to obtain information or control machines or process image. The applications of machine vision techniques has been expanded to various areas such as medical diagnostics, automatic manufacturing and surveillance, remote sensing, technical diagnostics, autonomous vehicle and in agriculture and food industry including the inspection of quality and grading of fruits and vegetables.

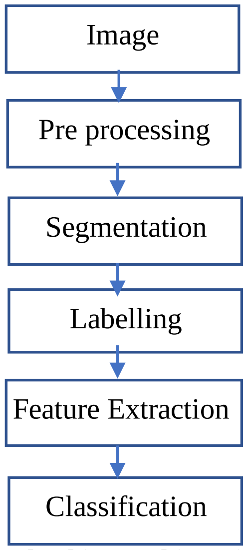

Fig. 1: Steps involved in Machine Vision Technique

3.2 Image Acquisition

The first stage of any vision system is the image acquisition. After the image has been obtained, this techniques uses all properties of elimination to increase features that can be obtained from the image. The image will be displayed in three dimensional through camera lens which in sense the reflected light rays will hit on pixel sensor. Each pixel contains information like intensity of light, information of reflected light back from 3D sensor. The two dimensional is used to project the three-dimensional object.

3.3 Pre processing

Pre-processing is in many cases concerned with taking one array of pixels as input and producing another array of pixels as output which in some way represents an improvement to the original array. This pre-processing step may remove noise, improve the contrast of the image, remove blurring caused by movement of the camera during image acquisition, it may correct for geometrical distortions caused by the lens.

3.4 Segmentation

Another way of extracting and representing information from an image is to group pixels together into regions of similarity. This process is commonly called segmentation. It is a process to find the object and separate it from the background image. And this process can be done by using Grey Scaling of Pre-processing step. In

2D - we would group pixels together according to the rate of change of their intensity over a region.

3D - we group together pixels according to the rate of change of depth in the image, corresponding to pixels lying on the same surface such as a plane, cylinder, sphere etc.

3.5 Labelling

Connected component labeling works by scanning an image, pixel-by-pixel (from top to bottom and left to right) in order to identify connected pixel regions. Connected component labelling works on binary or graylevel images and different measures of connectivity are possible. However, for the following we assume binary input images and *8-connectivity*. The connected components labeling operator scans the image by moving along a row until it comes to a point *p* (where *p* denotes the pixel to be labeled at any stage in the scanning process) for which *V={1}*. When this is true, it examines the four neighbors of *p* which have already been encountered in the scan. Based on this information, the labeling of *p* occurs as follows:

- If all four neighbors are 0, assign a new label to *p*, else
- if only one neighbor has *V={1}*, assign its label to *p*, else
- if more than one of the neighbors have *V={1}*, assign one of the labels to *p* and make a note of the equivalences.

After completing the scan, the equivalent label pairs are sorted into equivalence classes and a unique label is assigned to each class. As a final step, a second scan is made through the image, during which each label is replaced by the label assigned to its equivalence classes.

3.6 Feature Extraction

Feature extraction a type of dimensionality reduction that efficiently represents interesting parts of an image as a compact feature vector. This approach is useful when image sizes are large and a reduced feature representation is required to quickly complete tasks such as image matching and retrieval. Feature detection, feature extraction, and matching are often combined to solve common problems such as object detection and recognition, content-based image retrieval, face detection and recognition, and texture classification.

3.7 Classification

Classification is a type of supervised learning. It specifies the class to which data elements belong to and is best used when the output has finite and discrete values. It predicts a class for an input variable as well. Some of the key areas where classification cases are being used:

- To find whether an email received is a spam or ham
- To identify customer segments
- To find if a bank loan is granted
- To identify if a kid will pass or fail in an examination

3.8 Convolutional Neural Network

Convolution neural network gets the input image and convert it into a 3-dimensional array of pixel values then a convolution layer is applied on the image to get the basic features using feature map and the max pooling is applied to the images to further decrease the dimension of the convolution layer then all the pixel values are flattened and are input as a neural network to learn the features like shape, size and color. The neural network learns the extracted features using gradient decent algorithm. After learning, the modal is capable of prediction the objects sent as input.

Figure 2 shows the architecture of convolutional neural network. It consists of three layers which are input layer, hidden layer and the output layer. The input is given in the input layer and the process of comparison and separation are done in the hidden layer. After the completion of separation process, output will be obtained in the classification layer.

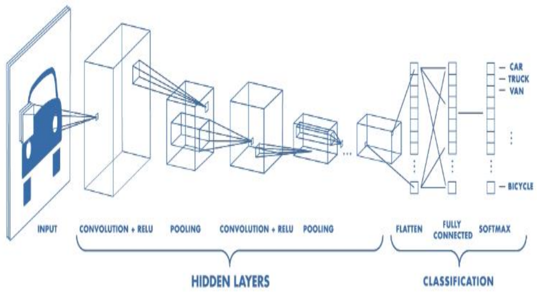

Fig. 2: Architecture of Convolutional Neural Network

4. GRADIENT DESCENT ALGORITHM AND ACTIVATION FUNCTIONS

The gradient descent algorithm, along with the back-propagation technique, is used to optimize the weights of the neural network. During the forward pass, the network uses the weights to predict the output. The "cost" or error value i.e. the difference between the actual and predicted output is back propagated through the network and the gradients are used to update the weight matrices. During each step, the gradient descent algorithm takes a small step in the direction which has the lowest slope. This is repeated several times until the global minimum is reached, and thus, the network is optimized. Equation 1 and 2 show the computations to get the gradients for each layer, from right to left. $\delta^{(l)}$ Denotes the error values of nodes in layer *l*. $\Theta^{(l)}$ denotes the weight matrix from layer *l* to layer *l*+1. *g* is the activation function, $z^{(l)}$ denotes the input values to layer *l*, and $a^{(l)}$ is the activation at layer *l*.

$$\delta^{(l)} = ((\Theta^{(l)})^T \delta^{(l+1)}) * g'(z^{(l)}) \tag{1}$$

$$g'(z^{(l)}) = a^{(l)} * (1 - a^{(l)}) \tag{2}$$

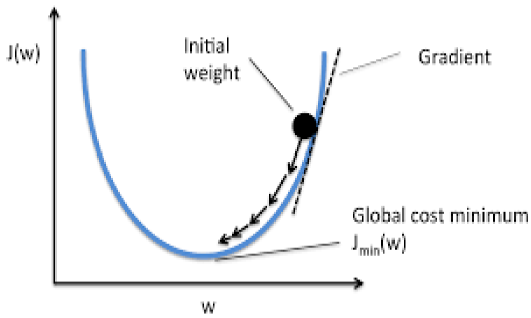

Fig. 3: Illustration of Gradient Descent

Figure 3 shows the visualization of cost where the global minimum is at the center. J (w) denotes the cost for the weights w. The steps taken towards reaching the minimum are highlighted in black.

The activation function is used to introduce non-linearity in the network. Without non-linearity, the output can only be a linear combination of the inputs. But the dataset may contain sequences whose underlying function cannot be approximated to a linear combination of inputs. Thus, non-linearity is required to successfully learn such sequences. Common activation functions include hyperbolic tangent shown in equation 3 and rectified linear tangent is shown in equation 4.

$$tanh(z) = \frac{2}{1+e^{-2z}} - 1 \tag{3}$$

$$relu(z) = max(0, z) \tag{4}$$

4.1 Smart Fruit Separator

The smart fruit separator is controlled by raspberry pi. The fruit separator has a pi camera to the quality of fruits. The raspberry pi is connected to a webserver and the information is communicated from server. Smart fruit separator consists of Microcontroller (Raspberry Pi 3), sensors and servo motor. Th Pi camera will capture the image and give their input to raspberry pi and it controls the separator and sends data to the web server. The separator module consists of servo motor which help us to separate the good fruits and rotten fruits in the separate baskets.

Figure 4 shows the working of the smart fruit separator the microcontroller is connected to the pi camera for predicting the fruits quality and image from the camera is sent to the feeded model where a CNN modal predicts whether it's a good 9fruit or rotten fruit and based on the response from server raspberry pi will decides whether the fruit should be moved to good basket or rotten basket with help of servo motor connected to Raspberry Pi.

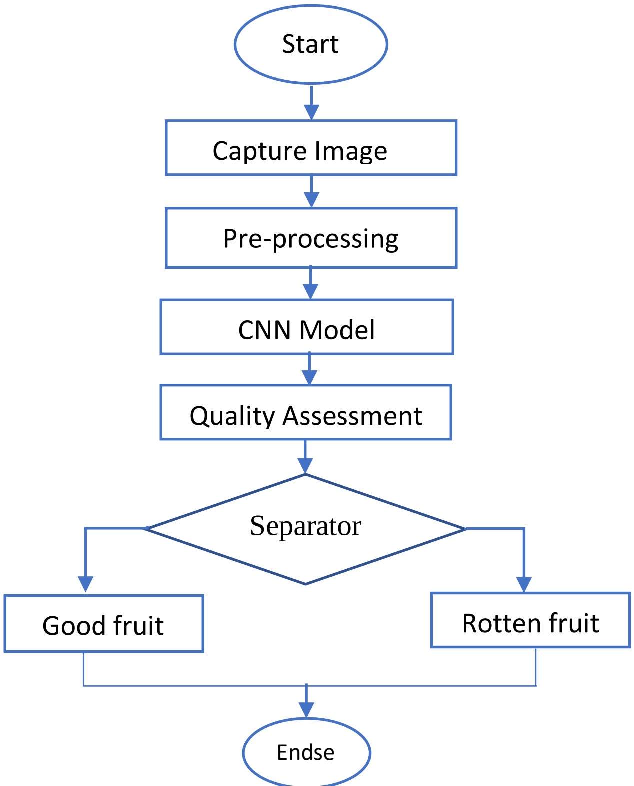

Fig. 4: Block Diagram of smart fruit separator

4.2 Working of Smart Fruit Separator

Initially, the sample dataset for good and rotten fruits of Apple, Orange, Banana are downloaded from Kaggle dataset website. The downloaded set consist of nearly 11000 images. The next process is to train model for the downloaded dataset using Convolutional Neural Network of machine learning technique. Here, we use Jupyter Notebook of python programming to train our model. But our system provided with Central Processing Unit (CPU) is slow for processing huge amount of dataset which consume long time span to complete the training process, so we are moving forward to Google Colab runtime environment is used as platform for the purpose of training the dataset. Google Colab provide Graphical Processing Unit (GPU) which is used for faster processing huge amount of data. The classification algorithm is developed with python programming Tensorflow (keras).

The classifier module is used to change the images to required shape and size. This process is carried over to reduce the error percentage while training the data. The classifier fit model is used to train the model. The fit model has to be provided with number of times the dataset to be trained(epochs). Then predict method is used to predict the belonging class of the input fruit image and it will display the belonging class.

As our project is based on IoT implementation, we have to run the trained model in the Raspberry Pi. But it is not possible to run the trained model in the small memory sized Microprocessor. Our trained model is to saved locally from the Google Colab and then saved model it is to feeded to Raspberry Pi python module.

The Raspberry Pi is connected to Pi camera and servo motor. When the python code starts Pi camera captures image and save the image in the specified location. The feeded model will consider input from the specified location and then the predict method will predict the belonging class of the fruit and it will send back to python code and servo motor will move the fruit the good or rotten basket depends on the fruit class obtained.

Fig. 5: Raspberry connected with pi camera

4.3 Dataset

The convolution neural network approach is tested on example images of some of the good and rotten fruits like oranges, apples and bananas.

Fig. 6: Good Fruit Dataset for apple

Fig. 7: Rotten Fruit Dataset for apple

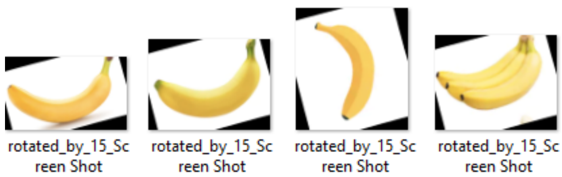

Fig. 8: Good Fruit Dataset for banana

Fig. 9: Rotten Fruit Dataset for banana

Fig. 10: Good Fruit Dataset for orange

Fig. 11: Rotten Fruit Dataset for orange

The above figures 6-11 shows the sample dataset of good and rotten fruits quality for Apple, Orange and Banana which are used to compare the quality of fruits are given in form of digital image.

4.4 Evaluation Metric

The modal accuracy of the testing data is 94.12% is accomplished with help of Gradient Descent Algorithm and the accuracy is stable with modal evaluation methods like Convolutional Neural Network. The modal can predict different types of fruits.

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_back

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_back

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_back

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_back

10901/10901 [==============================] - 5319s 488ms/step - loss: 0.1678 - acc: 0.9412
```

Fig. 12: Accuracy calculated with sample dataset

Figure 12 explains how much accuracy was obtained with sample datasets. The input digital fruit sample is compared with the trained datasets with the properties like size, shape and color. The accuracy obtained is dependent on the above properties.

5. RESULTS AND DISCUSSION

The Various quality detection algorithms like k-mean clustering, Edge Detection algorithm, Artificial Neural Networks, Convolutional Neural Networks, Support Vector Machine has been used to detect the quality of fruits and their accuracy and performances have been compared. By comparing with the existing proposed model, we have found another new technique for detecting the quality of fruits using Convolutional Neural Network algorithm and combined with IoT sensors like E-Nose are used to obtain high accuracy in an efficient way.

This project proposes a new technique for quality detection of fruits. The techniques is started by capturing the fruits image using pi camera of raspberry pi, and then the image is converted to base64 format (String) given to the web server using python flask framework. The base64 is again reverted back to image format and given as input to the trained model. The features are efficiently extracted from the sampled image. The extracted features based on the parameters like color, size and shapes. The CNN technique is used for checking the quality. The quality is determined by using the extracted features of fruits and values provided to the neural network during training. The proposed technique accurately detects the quality of fruits. The result will be obtained as good or rotten and again it will send back to the raspberry pi.This kind of system can be employed in juice plants, food protection industries, fruits and vegetables farm, packaging fruits and vegetables, etc..

```
!ls '/content/drive/My Drive/dataset/resized'

freshapples  freshoranges  rottenbanana
freshbanana  rottenapples  rottenoranges
```

Fig. 13: List of directories

Figure 13 shows the list of directories which are available in My Drive. ls is the command used to list the directories. mkdir is used for making a new directory.

```
/usr/local/lib/python3.6/dist-packages/ipyk
  from ipykernel import kernelapp as app
Found 10901 images belonging to 6 classes.
Found 10901 images belonging to 6 classes.
```

Fig. 14 Training Dataset

Figure 14 describes that the fruits are trained based on the size, shape and color. The training of good fruit dataset involves obtaining the features (shape, size and color) of good fruit. The training of rotten fruit dataset involves obtaining the features of rotten fruits.

6. CONCLUSION AND FUTURE SCOPE

The smart fruit separator is automated in such a way that the fruit is placed in the tray and the process of raspberry pi takes place here by obtaining the fruit image through the pi camera connected to the raspberry pi. The image is transformed to readable format of web server using python flask framework and it is given as the input to the training model. The sample Kaggle dataset for banana, apple, orange are used as training and testing model and its result obtained with an accuracy level of 94.6% using Convolutional Neural Network Algorithm. And some Sensors like E-nose, gas sensors were used to senses the fruit quality.

In future, the quality detection of our smart fruit separator should be compared with other mechanical and automated techniques and some new parameters or features can be added. The proposed model is capable of detecting a quality of one fruit at a time and this can be scaled up to detecting of multiple fruits of different kinds at a same time. The efficiency in detecting fruits quality accuracy level can be increased and time consuming can be reduced to short span of time. The smart fruit separator can also be upgrade to the next level like fully automated and it can be controlled through the mobile application.

7. REFERENCES

[1] Krithika Jayasankar, Karthika B, *"Fruit freshness detection using raspberry pi"* International Journal of Pure and Applied Mathematics, 1685-1691 ISSN: 1314-339, pp: 1685-1690, 2018.

[2] Mandeep Kaur, Reecha Sharma, *"ANN based Technique for Vegetable Quality Detection*, IOSR Journal of Electronics and Communication Engineering", ISSN: 2278-8735, pp:62-70, 2015.

[3] S.M. Shirsath, Sumit S. Telang , "*Fruit Quality Inspection using Image Processing*", Journal of Springer, ISSN:2395-4396, pp:1355-1359, 2015.

[4] Haisheng Gao, Fengmei Zhu and Jinxing Cai, ”*A Review of Non-destructive Detection for Fruit Quality* ”, Journal of Springer, IFIPAICT vol 317, pp:133-140, 2010.

[5] Rashmi Pandey, Sapan Naik, Roma Marfatia, *“Image Processing and Machine Learning for Automated Fruit Grading System”,* International Journal of Computer Applications, ISSN:0975-8887, pp:29-39, 2013.

[6] Van Huy Phan, Byung Ryong Lee, ”*An Image Segmentation Approach for Fruit Defect Detection Using K-Mean Clustering And Graph-Based Algorithm.”,* Journal of Springer, ISSN:2196-8896, pp:25-33, 2015.

[7] Baietto M, Wilson AD, *“Electronic-Nose application for fruit identification and quality grading”*. Journal of *Sensors*, ISSN:1424-8220, pp:899-931, 2015.

[8] Ms Rupali S. Jadhav ,S.S. Patil, *“A Fruit Quality Management System based on Image Processing”*, The International Organsation of Scientific Research Journals, ISSN: 2278-8735, pp: 01-05, 2013.

[9] Kedar Patil, Shriniwas Kadan, Suraj Kale *“Machine Vision Based Autonomous Fruit Inspection And Sorting”,* International Research Journal of Engineering and Technology, ISSN:2395-0072, pp:413-417, 2013.

[10] Saifalt Tamakuwala, Jenish, *“Quality Identification of Tomato Using Image Processing Techniques”,* International Journal of Electrical, Electronics and Data Communication(IJEEDC). ISSN:2320-2084, pp: 67-70, 2018 .

[11] Raja Sekar L, Ambika N, Divya V, “*Fruit Classification System Using Computer Vision”,* International Journal of Trend in Research and Development, ISSN:2394-9333, pp:22-26, 2018.

[12] Jyoti A Kodagali, *“A Role of Computer Vision in Fruits and Vegetables Among Various Horticulture Products of Agriculture Fields”,* Science Direct Journal, ISSN:2214-3173, pp: 01-21, 2018.

[13] Dakshayini Patil, *“Fruit disease detection and classification using image processing”.* International Journal for Research in Engineering Application & Management (IJREAM) . ISSN : 2454-9150, pp:128-131, 2018.

[14] Kyosuke Yamamoto, Wei Guo, Yosuke Yoshiko, *“On Plant Detection of Intact Tomato Fruits Using Image Analysis and Machine Learning”*, Journal of Sensors ISSN:1424-8220,pp:12191-12206, 2014.

[15] Bhanu pratap, Navneeth agarwal, sunil joshi, *“Development of ANN based efficient fruit recognition technique”,* The Global Journal of Computer Science, ISSN: 0975-4172, pp:18-28, 2014.

BIOGRAPHY

S. Krishna Kumar
Student
Dr. Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu

J. Kaviya
Student
Dr. Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu

G. Dilip Prakash
Student
Dr. Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu

K. Srinivasan
Professor
Dr. Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu

