Fruit Detection and Quality Recognition Using Image Processing

Submitted By

MD SHAKIL KHAN

ID-163432065

This Thesis Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering.

Supervised By

Khatuney Jannat Mafruza Mitu

Lecturer

Department of CSE

City University

CITY UNIVERSITY

DHAKA, BANGLADESH

AUGUST, 2021

CERTIFICATE

This is to certify that the work presented in this thesis entitled "**Fruit Detection and Quality Recognition Using Image processing"** is the outcome of the work done by **Md. Shakil Khan** under the supervision of **Khatuney Jannat Mafruza Mitu**, Lecturer, Department of Computer Science and Engineering, City University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation was held on **August 01, 2021**.

Khatuney Jannat Mafruza Mitu **Supervisor**
Lecturer,
Department of Computer Science and Engineering
City University, Dhaka, Bangladesh

Md. Rakib Uddin **Coordinator**
Lecturer & Coordinator,
Department of Computer Science and Engineering
City University, Dhaka, Bangladesh

Md. Safaet Hossain **Head**
Associate Professor and Head,
Department of Computer Science and Engineering
City University, Dhaka, Bangladesh

DECLARATION

I hereby declare that; this project has been done by me under the supervision of "**Khatuney Jannat Mafruza Mitu",** Lecturer, Department of CSE City University. I also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

Supervised By:

Khatuney Jannat Mafruza Mitu
Lecturer,
Department of Computer Science and Engineering
City University, Dhaka, Bangladesh

Submitted By:

Md Shakil Khan
Id: 163432065
Batch: 43rd
Department of Computer Science and Engineering
City University, Dhaka, Bangladesh

DEDICATION

"This dissertation is dedicated to my parents and teachers for all their continuous support, love and inspiration"

ABSTRACT

Image Processing is a technique which converts an image into a digital image to obtain some enhancement or to select some effective information from it. Classification of fruit quality or grading is helped by detection of defects present on fruit peel. As there is a great demand for high-quality fruits in the market, the task of defect detection in fruit is very vital in the agricultural industry. However, defect detection by the human is labor-intensive and time-consuming. This paper presents the fruit detection using improved multiple features-based algorithm. This system minimizes error and also speeds up the time of processing. The objective of this work is to present a novel method to detect surface defects of fruit using RGB images. The Detection Efficiency is achieved up to 99% for different fruit image on tree, captured at different positions. The method uses pre-processing, segmentation, edge-detection and feature extraction to classify the fruit as defected or fresh.

ACKNOWLEDGEMENT

First of all, I would like to thank our Creator Almighty Allah who has given me a sound mind and health while I am at work and given me the ability to work hard successfully.

Secondly, I would like to thank and express my deepest appreciation and sincere gratitude to my supervisor **Khatuney Jannat Mafruza Mitu** who inspired me to take pride in my research. Her enthusiasm for research efforts surely will have a significant effect on my future research. Her advice throughout this process kept me focused on the right direction. Her endless patience, scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism, valuable advice, reading many inferior drafts, and correcting them at all stages have made it possible to complete this thesis.

In addition, I would like to express my heartiest graduate to **Md. Safaet Hossain**, Associate Professor, and Head, Department of the CSE, for his kind help to finish my research and also to other faculty member and the staff of CSE department of City University.

I would like to thank our entire course mate in City University, who took part in this discuss while completing the course work.

Finally, I must acknowledge with due respect the constant support and patients of my parents.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

SVM	Support Vector Machine
CNN	Convolutional Neural Network

Chapter 1

Introduction

In today's world, we can see every system is getting automated and manual interference in the system becomes non-economical solution as well as a time-consuming task. In case of fruits, it's very much sensitive product as its food item and hygiene becomes the most important parameter while handling it. Through this project, we are going to put the automated fruit quality sensing, detection and acceptance or rejection of the product for further use or discarding purpose. This automated system is designed to overcome the problems of manual techniques, here the hardware model is designed using conveyor system. In Agri department science, images are the important source of data and information. To reproduce and report such data, photography was the only method used in recent years. It is difficult to process or quantify the photographic data mathematically. The image processing technology circumvent these problems based on the advances in computers and microelectronics associated with traditional photography. To improve images from microscopic to the telescopic visual range and offers a scope for their analysis. Several applications of image processing technology have been developed for the agricultural operations. These applications involve implementation of the camera-based hardware systems or color scanners for inputting the images. The computer-based image processing is undergoing rapid evolution with ever changing computing systems. The dedicated imaging systems available in the market, where the user can press a few keys and get the results, are not very versatile and more important, they have a high price tag on them. The aim of image processing and computer vision techniques in the food and farming industry.

1.1 Motivation

This concept motivates us in developing such a model which can recognize a fruit and predicts its name. There may be a variety of applications of fruit recognition in agricultural work when we are to recognize thousands of fruit images in a less amount of time.

Automatic recognition of facial expression is a long-term objective in image understanding, pattern classification; Analysis includes both measurement of fruit detection and recognition of expression. There has been a global rush for fruit detection and recognition over the last few years [1-4].

It can also be applied in automating the billing process at a fruit shop where the model can recognize the fruit and calculate its price by multiplying with weight.

In this article, we will recognize the fruit where the Convolutional Neural Network will predict the name of the fruit given its image. We will train the network in a supervised manner where images of the fruits will be the input to the network and labels of the fruits will be the output of the network. After successful training, the CNN model will be able to correctly predict the label of the fruit.

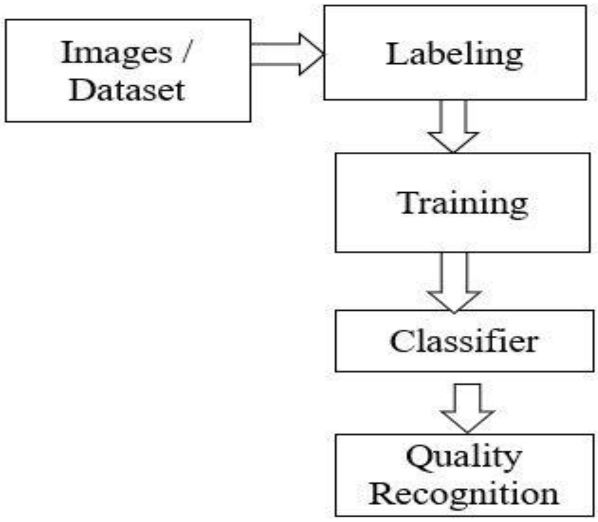

Fig. 1.1: The complete system overview of our paper

Even though some existing works have discussed fruit detection and recognition separately, none of these existing works have considered fruit detection, tracking and recognition combined. Moreover, even though some authors applied different approaches for different purposes, none of them have applied support vector machine for fruit detection and quality recognition together to detect different type of fruit image.

1.2 Objective and Research Challenges

The objective of Fruit Recognition using image processing is design an incremental model recogniz**e** the fruits based on size**,** shape and colour of the fruit ignoring external features l ike environment**,** noise and background**.** This just focus the image of particular fruit and id entify the fruit**.**

In our work, the main objectives are to design and build a complete system to detect fruit detection, recognize quality recognition. The whole system is divided into several parts; first to create a database with fruits images of different individuals. Then create a model with this database. Finally detect different type of fruits from real time video. The task of quality recognition is particularly difficult for two reasons: 1) There does not exist a large database of training images and 2) classifying quality of the fruits can be difficult depending on whether the input image is static or a transition frame into a fruit detection.

A common approach to the problem of fruit detection in images is to design a deep learning network and train a model to locate objects. Using bounding boxes to identify regions containing fruit. However, this requires sufficient data and presents challenges for small datasets. Transfer leaning, which acquires knowledge from a source domain and brings that to a new target domain, can produce improved performance in the target domain. This investigation is based on three datasets: two containing tomatoes and one containing strawberries. Experimental results indicate that transfer learning can enhance prediction with limited data.

After all, from the above-mentioned references, the following shortcomings are observed:

• There are few individual studies that have applied SVM Classifier. In addition, there are no well-known studies that have combined all these techniques together at the same dataset to investigate the variations in technique-based findings

• There is no significant study that has applied the above-mentioned Support Vector Machine techniques for fruit detection and recognition.

The main aims:

- To detect defect fruits.
- To recognize defect Fruit from images.
- To know the current situation of the fruit.
- To know the difference between the algorithms which are used.
- To reduce labor force.
- To take a little time for the fruit's quality inspection.
- To be efficient in classifying the different types of fruits and into one of the following rotten fruits and fresh fruits.
- To know the fruits name easily

Finally, to use a complete model for detecting fruits, recognizing rotten and fresh fruits in real time.

1.3 Contribution to Fruit Detection and Quality Recognition

To address the above-listed shortcomings, in our present work, we address all above discrepancies by introducing a framework to detect fruit and recognize quality of the fruits. To the best of our knowledge, our work is the first attempt to apply support vector machine (SVM), TensorFlow library and CNN for fruit detection and quality recognition. With the present work, we specify the different features of fruit for detection and quality recognition. The major contributions of this paper are listed as follows:

• We apply CNN, TensorFlow, SVM classifiers to extract the features for fruit detection and SVM and TensorFlow classifier for fruit detection and quality recognition.

• To detect and recognize the fruit, we identify through our results that CNN algorithm performs better

• We apply Convolutional Neural Network (CNN), Support Vector Machine (SVM) algorithm, and TensorFlow library to recognize the fruit detection in real time.

• Our work also shows the importance of fruit detection and quality recognition in computer interaction.

1.4 Research Outline

The rest of the thesis is (for both SVM, TensorFlow and CNN) as follows: Section 2 presents the related work, section 3 presents the methods regarding the issue of this work where section 3.1.1 presents the work on fruit detection, afterward, section 3.1.2 covers about feature extraction and section 3.1.3 present the deeper insight into fruit detection and quality recognition. Section 4 explains the results of the works. Section 5 includes discussion. Conclusion and suggestions for future work are presented in Section 6.

Chapter 2

Background Study

Object recognition has been studied for more than four decades [1]. Significant efforts have been paid to develop representation schemes and algorithms aiming at recognizing generic objects in images taken under different imaging conditions (e.g., viewpoint, illumination, and occlusion). Within a limited scope of distinct objects, such as handwritten digits, fingerprints, faces, and road signs, substantial success has been progress towards object categorization from images has been made in the recent years [3]. Object recognition along with machine learning algorithm and image processing have been implemented in fruit classification as well. Here we present a discussion on fruit detection and quality recognition using SVM, CNN and TensorFlow.

2.1 SVM Algorithm Analysis for Fruit Detection and Quality Recognition

Recognition has always been a highly researched topic. Recognition includes authentication. Authentication involves a one-to-one comparison to verify a claimed identity. Identification often involves a one-to-many comparison to retrieve an initially unknown identity from a known possibility. So, recognition is one type of classification where the problem is to identify the group of the identity.

This paper [1] is based on the use of speeded up robust feature. The method extracts the local feature of the segmented image and describes the object recognition. The basic steps are to create a database of image to be classified. Then image pre-processing done by means of various image processing techniques to improve the quality of the image and later several filters are applied to de-noise the image. Finally, image classifiers are used for classification. Image is converted from RGB image to intensity image. Based on speeded up robust technique local feature is extracted and described. To characterize the texture of the input image, statistical measurement of randomness. Other features extracted such as object recognition, image registration, recognizing parameter and image retrieval. Objects and boundary lines of images are obtained by image segmentation. Then feature extraction like shape, size, color and texture of fruits are calculated using algorithm. Then for disease classification pattern matching is applied. The system also includes specific skin defect detection algorithms not only to locate them, but also to determine their distribution, which can affect to their assignment to a standard category.

[2] to extract fruit features which are further classified using SVM. However, for real time implementation of such algorithms, time complexity plays a crucial role which usually traded off with accuracy [3].

This paper elaborated the fruit quality and propose a novel classification method based on a multi-class kernel support vector machine (SVM). First, fruit images were acquired by a digital camera, and then the background of each image was removed by a split-and-merge algorithm. Second, the color histogram, texture and shape features of each fruit image were extracted to compose a feature space. Third, principal component analysis (PCA) was used to reduce the dimensions of feature space. First, we use Image Segmentation with Spilt and Merge Algorithm which will remove the background area and based on a quadtree partition of an image. This method starts at the root of the tree that represents the whole image. If it is found inhomogeneous, then it is split into four son-squares. Conversely, if four son-squares are homogeneous, they can be merged as several connected components (the merging process). Then the histogram is merely the count of pixels that have each possible color. Third step is using Unser's Texture Features, Gray level co-occurrence matrix and local binary pattern are good texture descriptors. It eliminates the components in the data set that contributes the least variation.

2.2 TensorFlow Library Analysis for Fruit Detection and Quality Recognition

For the purpose of implementing, training and testing the network described in this paper we used the TensorFlow library [4]. This is an open-source framework for machine learning created by Google for numerical computation using data flow graphs. Nodes in the graph represent mathematical operations, while the graph edges represent the multidimensional data arrays called tensors. The main components in a TensorFlow system are the client, which uses the Session interface to communicate with the master, and one or more worker processes, with each worker process responsible for arbitrating access to one or more computational devices (such as CPU cores or GPU cards) and for executing graph nodes on those devices as instructed by the master. TensorFlow offers some powerful features such as: it allows computation mapping to multiple machines, unlike most other similar frameworks; it has built in support for automatic gradient computation; it can partially execute subgraphs of the entire graph and it can add constraints to devices, like placing nodes on devices of a certain type, ensure that two or more objects are placed in the same space etc. Starting with version 2.0, TensorFlow includes the features of the Kera's framework [5]. Kera's provides wrappers over the operations implemented in TensorFlow, greatly simplifying calls, and reducing the overall amount of code required to train and test a model. TensorFlow is used in several projects, such as the Inception Image Classification Model [2]. This project introduced a state-of-the-art network for classification and detection in the ImageNet Large-Scale Visual Recognition Challenge 2014. In this project the usage of the computing resources is improved by adjusting the network width and depth while keeping the computational budget constant [6]. Another project that employs the TensorFlow framework is Deep Speech, developed by Mozilla. It is an open-source Speech-To-Text engine based on Baidu's Deep Speech architecture [7]. The architecture is a state-of-the-art recognition system developed using end-to-end deep learning. It is simpler that other architectures and does not need hand designed components for background noise, reverberation or speaker variation. We will present the most important utilized methods and data types from TensorFlow together with a short description for each of them.

2.3 CNN Algorithm Analysis for Fruit Detection and Quality Recognition

Convolution neural network (CNN) is a class of deep learning that has accomplished creative outcomes in different fields such as natural language processing and image recognition. The layers of a CNN consist of an input layer, an output layer, and a hidden layer. The hidden layer includes multiple convolutional layers, pooling layers, fully-connected layers, and normalization layers.

CNN is used to build a deep learning model for the prediction of fruits. Total of 31 different fruits classes are there Model CNN fruit convolutional-neural networks fruits machine-learning-models CNN-classification fruit-recognition. Most of the current works implement techniques that are not robust to noise, which require the implementation of systems to maintain a constant luminosity and focus on a single type of fruit. In order to make systems based on machine vision more robust, techniques such as CNN have shown their efficiency. For instance, a CNN was implemented to classify 1000 different categories of images among which were included landscapes, foods, and tools. It could obtain 84.7% accuracy in the classification of the images in their respective categories, surpassing the existing results achieved by other types of techniques. As a result of the CNN boom, they have been implemented in different applications. CNN boom is used for the detection of cancer from magnetic resonance images, obtaining a 98.6% accuracy in the classification of the images [2]. The authors seek to detect vehicles [5] for which a type of CNN is implemented. It is called faster R-CNN, which not only allows identifying the category which an image but also generates regions in the image where the elements of interest are located without significantly affecting the network classification time [1]. Using this type of network, they put it to the test with the KITTI database [6], evaluating the network in three different types of difficulty, obtaining 95.14%, 83.73%, and 71.22% accuracy in the detection of vehicles. CNNs are implemented to detect and identify specific products in the refrigerator of a home such as milk or juices to alert the user when any of these is not found, obtaining a 96.3% accuracy in identifying the products [5]. In recent years, a variation of the CNN structure has been working, implementing a Directed Acyclic Graph (DAG) structure which is presented in [7]. The main advantage of this type of network is the ability to use several ramifications in the design of the CNN architecture in order to optimize the processing times and learn a greater number of

characteristics of the images. An application of a CNN with structure type DAG is presented, focused on the recognition of people´s heartbeat types, where they obtained a

97.15% accuracy in the classification of cardiac abnormalities, surpassing most of the techniques currently used [4]. his article presents as a contribution to the state of the art, evaluation of a DAG-CNN to classify 8 different types of fruit and detect if they are fresh for consumption or not. The first stage corresponds to materials and methods, which presents a general scheme of the implemented system, the database, architecture, and training parameters. The second stage shows the training and results of the network, an analysis of the correct and incorrect classification cases, and the graphic user interface designed to use the network. In the last part of the article, the conclusions about the obtained results are presented.

A convolutional layer is defined like this:

```
Conv2D (
        no filters,
        filter sizes,
        strides,
        padding,
        names=None
        )
```

Computes a 2D convolution over the input of shape [batch, in height, in width, in channels] and a kernel tensor of shape [filter height, filter width]. This op performs the following:

• Flattens the filter to a 2-D matrix with shape [filter height * filter width * in channels, output channels].

• Extracts image patches from the input tensor to form a virtual tensor of shape [batch, out height, out width, filter height * filter width * in channels].

• For each patch, right-multiplies the filter matrix and the image patch vector.

• If padding is set to" same", the input is 0-padded so that the output keeps the same height and width; else, if the padding is set to" valid", the input is not 0-padded, thus the output may be smaller across the width and height

```
MaxPooling2D (
filter sizes,
 strides,
 padding,
 names=None
        )
```

Performs the max pooling operation on the input. filter size represents size of the window over which the max function is applied. strides represent the stride of the sliding window for each dimension of the input tensor. Similar to the Conv2D layer, the padding parameter can be" valid" ‘or" same".

```
Activation (
        operations,
        names=None
    )
```

Computes the specified activation function given by the operation. We are using in this project the rectified linear operation - max (features, 0).

```
Dropout (
        prob,
        names=None
    )
```

Randomly sets input values to 0 with probability prob. The method scales the non-zero values by 1 / 1 - prob in order to preserve the sum of the elements.

Chapter 3

Methodology

In this chapter, we explain the proposed method that has been used for designing the fruit detection system introducing the data collection and feature extraction. Later, we present how we can build the system for fruit detection and quality recognition. And finally, we present how we can classify and incorporate the data for quality recognition.

3.1 SVM for Fruit Detection and Recognition

In this section, we present our framework and focus on several factors for fruit detection and quality recognition in real-time (Fig. 3.1). The process used in our proposed system can be explained using the following flowchart.

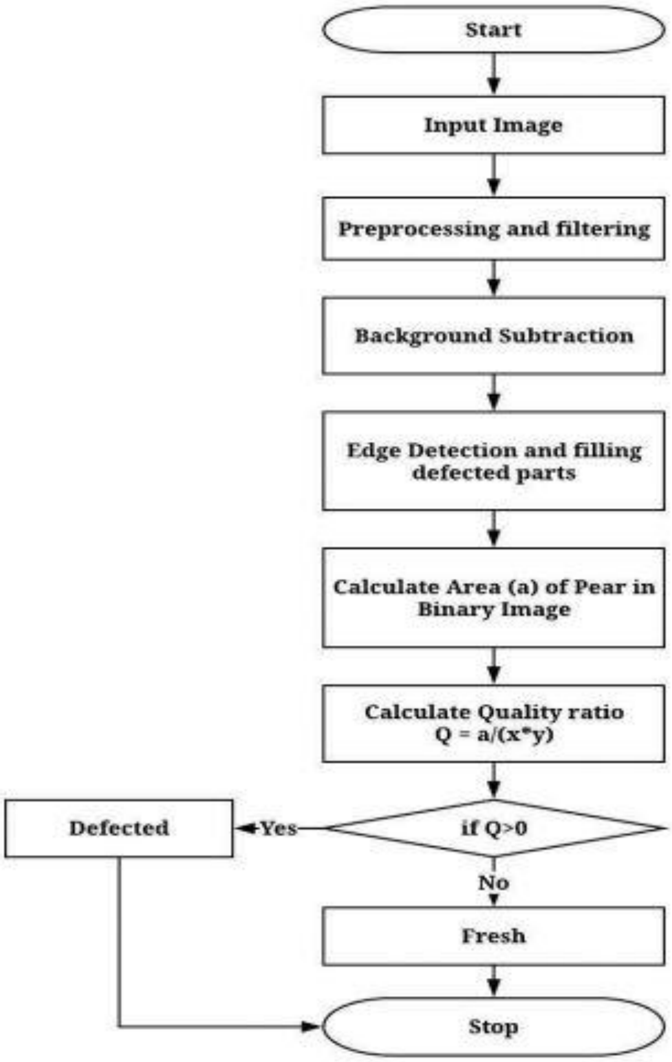

Fig. 3.1: Flowchart of the whole system

As we shown in the above Fig. 3.1, that the input is a real-time video for our work. The whole system is divided into 2 major phases called training phase and testing phase. The process used in our training phase can be explained using the following figure

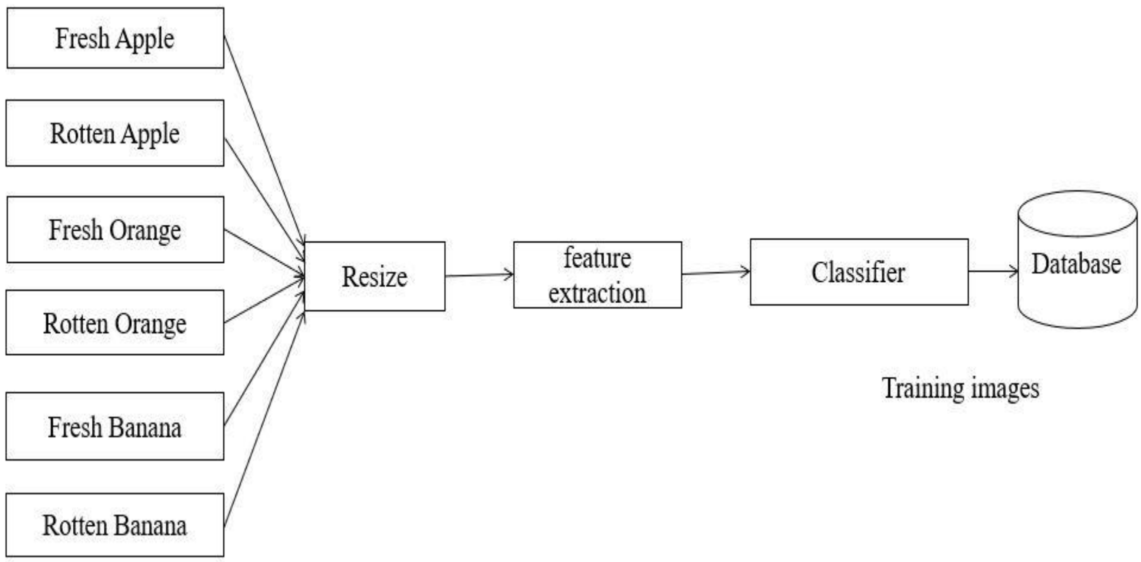

Fig. 3.2: Training phase

The training phase consists of some parameters. We collect data for our system from real-time through fruit detection and feature extraction. Then the data are stored in a database. A classifier is then used to create a train model from the database. After getting the train model the next step is testing. The process used in our testing phase can be explained using the following figure

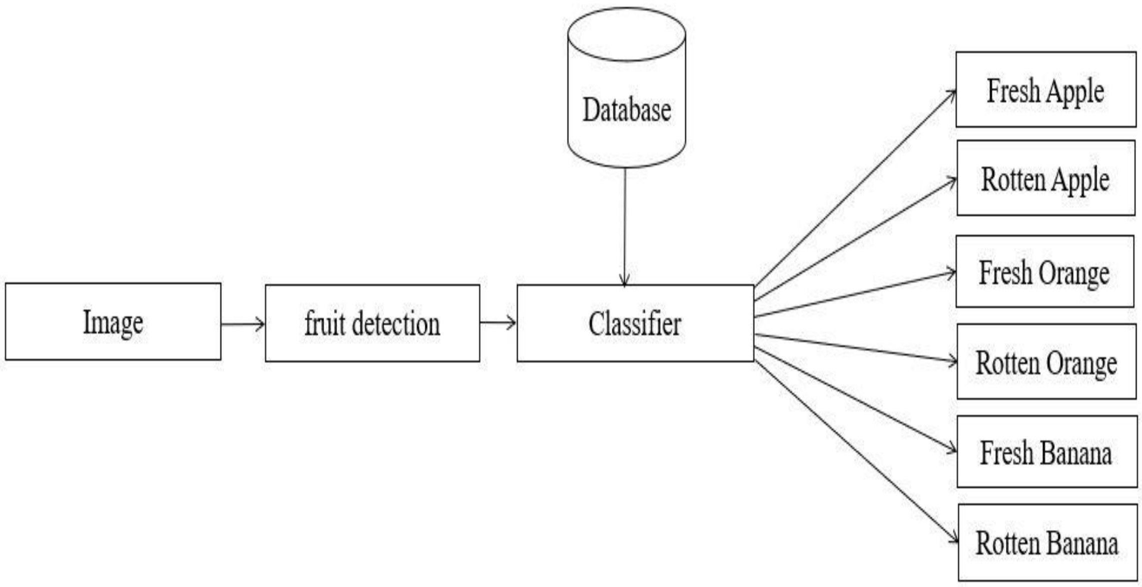

Fig. 3.3: Testing phase

In the testing phase, we use a webcam to detect fruits from real-time video. Then the fruit features are passed to the classifier, which was used to create the train model. Then the classifier classifies the fruit detection into several classes. These classes are the output of our work. The program works in three different steps namely fruit detection, feature extraction and the quality recognition. The following (Fig. 3.4) shows each step of our works

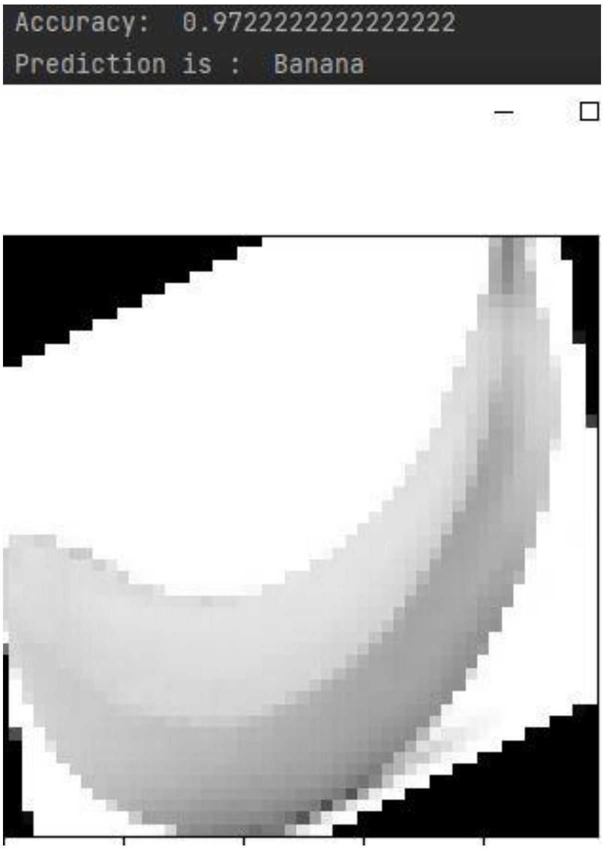

Fig. 3.4: Fruit Detection and Quality Recognition from images

In the first phase, our program tries to detect the fruit in the input videos. When the fruit is detected, the program draws a rectangle and tracks the fruit in the. Detection of fruits in a given video is independent in a video. Once the face is detected by the program, the next phase is to extract the features correctly to recognize the quality of the fruit. We have trained our model for a certain number of people of different range of ages by extracting l features for different type of fruits from some videos. Now with the help of the trained model, in the last phases, our program tries to recognize fruits in the video. After fruits quality recognition, whether it is successful or not it goes to the next step i.e., fruit detection.

3.1.1 Fruit Detection

The technique is used for analysis the pictures and to improve its quality of unprocessed is known as image processing. The raw images or pictures can be obtained from the cameras deployed on aircrafts, space shuttle, satellites or the images captured in daily routine for numerous objectives. A number of image processing methods have been developed in the last few years [1]. Various approaches explored for image processing are acquired from armed forces scouting flights, interplanetary explorers and rockets. Some factors like effortless accessibility of prevailing personnel processors, big dimensional reminiscence equipment's, and graphic software etc. play a fundamental role in the popularity of image processing techniques. It is used to find its usefulness in various areas like publishing business; article dispensation, armed forces, forensic Studies, explicit sculptures, film business, non-destructive assessment, fabric discipline and medical Imaging. Image scanning, image storing, image improvement and image elucidation are the general phases involved in image or picture processing. The image processing is mainly of two types [2]. These types are analog image processing and digital image processing. In analog picture processing, electrical methods are used to alter the picture. Different kinds of picture processing methods have been implemented in the last few years for analyzing the farming pictures like vegetables and fruits for acknowledgment and categorization causes. The scheme of fruit detection can be implemented in the form of picture text describer. This scheme comprises ability for the description of low-level image characteristics or fruit pictures contents [3].

A number of techniques have been proposed for the detection and categorization of fruit pictures on the basis of color and shapes. The color and texture of various fruits depends on their growth. Color and texture are considered the primary quality of natural descriptions [4]. These factor also a play a significant character in image perception. Though, dissimilar fruit images can have alike or equal color and shape standards. Therefore, color or shape characteristics scrutiny techniques are not vigorous and adequately efficient for the identification and differentiation of fruits descriptions. The fruit detection scheme may be implemented for educational reasons in order to enhance knowledge, particularly for little children and down disease patients, of fruits prototype detection on the basis of fruit detection outcomes [5]. The scheme of fruit recognition can also be implemented in grocery stores so that consumers can tag their purchase with the help of computerized fruit detection system.

Numerous issues have to be conquered for enabling the scheme to execute computerized detection of the type of fruit or vegetable with the help of pictures taken from the camera. In a fruit recognition system, certain factors like unsure and erratic brightness circumstances in the field surroundings, uneven and multifaceted awning configurations and unreliable shade, figure and dimension of the fruit affects the accurateness of fruit identification and localization [6]. Also, some barriers like leaves, twigs, and other fruits also restrict the precision of fruit recognition in awning pictures. Various researches have been conducted in the last few years for the recognition of fruits in alike external atmosphere. The tradition techniques of fruit recognition used different kind of picture sensors, a variety of picture scrutinizes and soft calculation techniques. Support Vector Machine classifier is a supervised statistical learning algorithm. This approach is utilized for linear and non-linear deterioration scrutiny and prototype categorization. SVM approach segregates the two classes with an utmost fringe amid them with the help of a hyper-linear plane for linear separable categorization.

The characteristic vectors are planned to a novel characteristic space in a non-linear separable manner for non-linear separable categorization. After this, image classification is performed on the basis of linear SVM segregation. A recurrent network employs Backbone Propagation Neural Network (BPNN) algorithm. The weights of neural network get fixed after training. These weights can be utilized for the computation of output values for novel question images. These images do not exist in the learning database. Decision tree algorithm computes the class relationship by dividing a dataset into unvarying subsets in repetitive manner [7]. The acceptations and refusal of class labels at every intermediate phase are permitted by the Hierarchical classification model.

This technique has three sections. These are partitioning of nodes, detection of terminal nodes and distribution of class label to the terminal nodes. These classifiers are based on the hierarchical rule-based technique. These classifiers use nonparametric approach. Several stochastic relations are driven to define the features of an image fuzzy measure classification process [4]. This classification process combines the different kinds of stochastic are combined wherein the constituent of this set of properties are fuzzy in nature. It gives the chance to explain different groups of stochastic features in the analogous form. The stochastic approach is used by this classification technique. The threshold choice and fuzzy integral are two factors that decide the performance and accuracy of this classification.

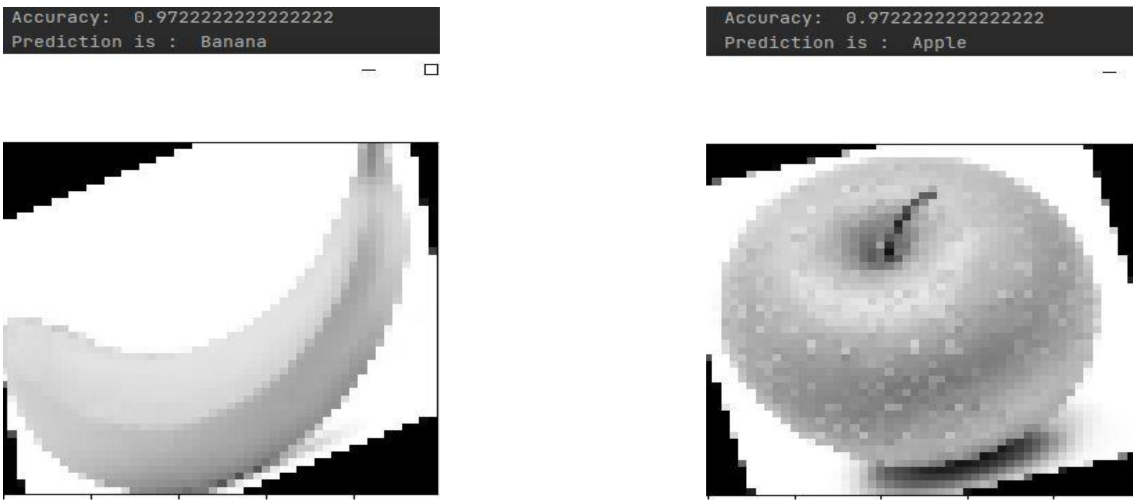

Fig. 3.5: Fruit Detection and Quality Recognition Using SVM

3.1.2 SVM Classifier

The approach of SVM classifier will be applied which will classify the defective and non-defective regions. The SVM classifier will detect the percentage of area defective, it is an effective classifier which is used to perform regression, classification as well as general pattern recognition and hence it is called SVM classifier. It highly generalized the performance without including any prior knowledge even in the case when the input space is very high; this classifier is one of the best classifiers amongst all. It is used for binary classification and for solving multiclass issue.

3.1.3 Feature Extraction Using SVM Algorithm

The main intention of fruit detection and recognition is to identify fruits quality detection. Then feature extraction is performed in order to enhance the contrast of the image and the fruit is classified by using SVM classifier whether it is an affected fruit or a normal fruit. Finally Gray level Co-occurrence matrix is used to validate the result based on the classification. The farmers who primarily depend upon enhance the contrast of the image and the fruit is these plant crops get highly affected if the production classified by using SVM classifier whether it is an gets decreased. The only way to increase the yield is affected fruit or a normal fruit.

3.1.4 Fruit Detection and Quality Recognition

To identify quality of the fruits, fruit detection and quality recognition is one of the most significant applications of computer vision. Although some techniques have been applied in this area during the last few years, in this paper, for doing this significant task we propose Support Vector Machine (SVM). Deepika Shukla Comp. (2016) have proposed an algorithm mainly focused on fruit detection and recognition; they have recognized nine different classes of fruits. Fruit image dataset are obtained from web as well as certain images are acquired by using mobile phone camera. These images are pre-processed to subtract the background and extract the blob representing fruit. For representing fruits and capturing their visual characteristics, combination of color, shape and texture features are used. These feature datasets are further passed to two different classifiers multiclass SVM and CNN.

The color image is firstly converted to grayscale by GLCM (Gray Level Co- occurrence Matrix). The image is further converted to binary image. Further, Morphological operations are used to fill the holes and extract the largest blob or object from the image which would further be considered as fruit. After that this largest blob is cropped and the binary values are replaced with original intensity values. From the experiments it can be concluded that the combination of color texture and shape gives better or comparable results in most of the cases than when any two categories of features are used. Also, the second conclusion which can be made is that CNN gives better results for this case than SVM.

3.2 TensorFlow for Fruit Detection and Quality Recognition

In this term, we use TensorFlow library for fruit detection and quality recognition. This method just like CNN, also include training and testing phases. In training phase, we use TensorFlow library to create a different train model by the same database. And in testing phase we use TensorFlow library to recognize fruit detection and quality recognition. The following flowchart shows the overall system using TensorFlow

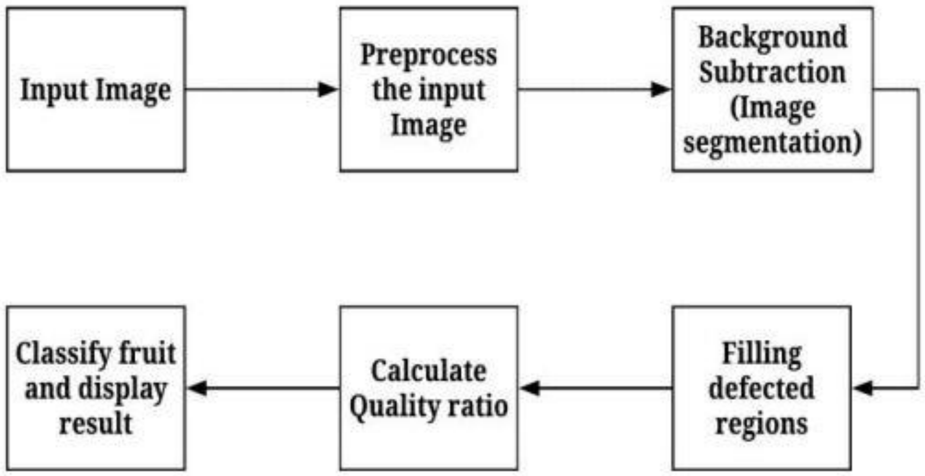

Fig. 3.6: Flowchart of Fruit Detection and Quality Recognition Using TensorFlow

3.2.1 OpenCV-Python

OpenCV-Python is a library of Python bindings designed to solve computer vision problems.

Python is a general-purpose programming language started by Guido van Rossum that became very popular very quickly, mainly because of its simplicity and code readability. It enables the programmer to express ideas in fewer lines of code without reducing readability.

Compared to languages like C/C++, Python is slower. That said, Python can be easily extended with C/C++, which allows us to write computationally intensive code in C/C++ and create Python wrappers that can be used as Python modules. This gives us two advantages: first, the code is as fast as the original C/C++ code (since it is the actual C++ code working in background) and second, it easier to code in Python than C/C++. OpenCV-Python is a Python wrapper for the original OpenCV C++ implementation.

OpenCV-Python makes use of NumPy, which is a highly optimized library for numerical operations with a MATLAB-style syntax. All the OpenCV array structures are converted to and from NumPy arrays. This also makes it easier to integrate with other libraries that use NumPy such as SciPy and Matplotlib.

OpenCV Python is used to identify the ripe fruit**.** Several Python modules are required like matplotlib, NumPy, pandas, etc. and all the modules are pre-installed with Ultra96 board image. I have chosen a sample image from internet for showing the implementation of the code

3.2.2 MobileNet-SSD Model

The mobilenet-ssd model is a Single-Shot multibox Detection (SSD) network intended to perform object detection. This model is implemented using the Caffe* framework. For details about this model, check out the repository. The model input is a blob that consists of a single image of 1x3x300x300 in BGR order, also like the densenet-121model.

MobileNet is a fruit detector released in 2017 as an efficient CNN architecture designed for mobile and embedded vision application. This architecture uses proven depth-wise separable convolutions to build lightweight deep neural networks. More information about the architecture can be found here**.**

The SSD architecture is a single convolution network that learns to predict bounding box locations and classify these locations in one pass. Hence, SSD can be trained end-to-end.

SSD (Single Shot MultiBox Detector) is a popular algorithm in fruit detection. It's generally faster than Faster RCNN. In this post, I will give you a brief about what is fruit detection, what is TensorFlow API, what is the idea behind neural networks and specifically how SSD architecture works.

MobileNet is a CNN architecture model for Image Classification and Mobile Vision. There are other models as well but what makes MobileNet special that it very less computation power to run or apply transfer learning to. This makes it a perfect fit for Mobile devices, embedded systems and computers without GPU or low computational efficiency with compromising significantly with the accuracy of the results.it is also best suited for web browsers as browsers have limitation over computation, graphic processing and storage.

3.2.3 MobileNet Architecture

- MobileNets for mobile and embedded vision applications is proposed, which are based on a streamlined architecture that uses depth wise separable convolutions to build light weight deep neural networks.
- Two simple global hyper-parameters that efficiently tradeoff between latency and accuracy are introduced.

The core layer of MobileNet is depth wise separable filters, named as Depth wise Separable Convolution. The network structure is another factor to boost the performance. Finally, the width and resolution can be tuned to tradeoff between latency and accuracy.

For Example, in the image below the SSD model has detected Apple, Orange, Banana, Mango in a single shot. It detects different objects in a single shot.

3.3 CNN for Fruit Detection and Quality Recognition

Convolutional neural networks (CNN) are part of the deep learning models. Such a network can be composed of convolutional layers, pooling layers, ReLU layers, fully connected layers and loss layers [7]. In a typical CNN architecture, each convolutional layer is followed by a Rectified Linear Unit (ReLU) layer, then a Pooling layer then one or more convolutional layer and finally one or more fully connected layer. A characteristic that sets apart the CNN from a regular neural network is taking into account the structure of the images while processing them. Note that a regular neural network converts the input in a one-dimensional array which makes the trained classifier less sensitive to positional changes. Among the best results obtained on the MNIST [4] dataset is done by using multi-column deep neural networks. As described in paper [7], they use multiple maps per layer with many layers of non-linear neurons. Even if the complexity of such networks makes them harder to train, by using graphical processors and special code written for them. The structure of the network uses winner-take-all neurons with max pooling that determine the winner neurons. Another paper [2] further reinforces the idea that convolutional networks have obtained better accuracy in the domain of computer vision. In paper [3] an all-convolutional network that gains very good performance on CIFAR-10 [3] is described in detail. The paper proposes the replacement of pooling and fully connected layers with equivalent convolutional ones. This may increase the number of parameters and adds inter-feature dependencies however it can be mitigated by using smaller convolutional layers within the network and acts as a form of regularization. In what follows we will describe each of the layers of a CNN network.

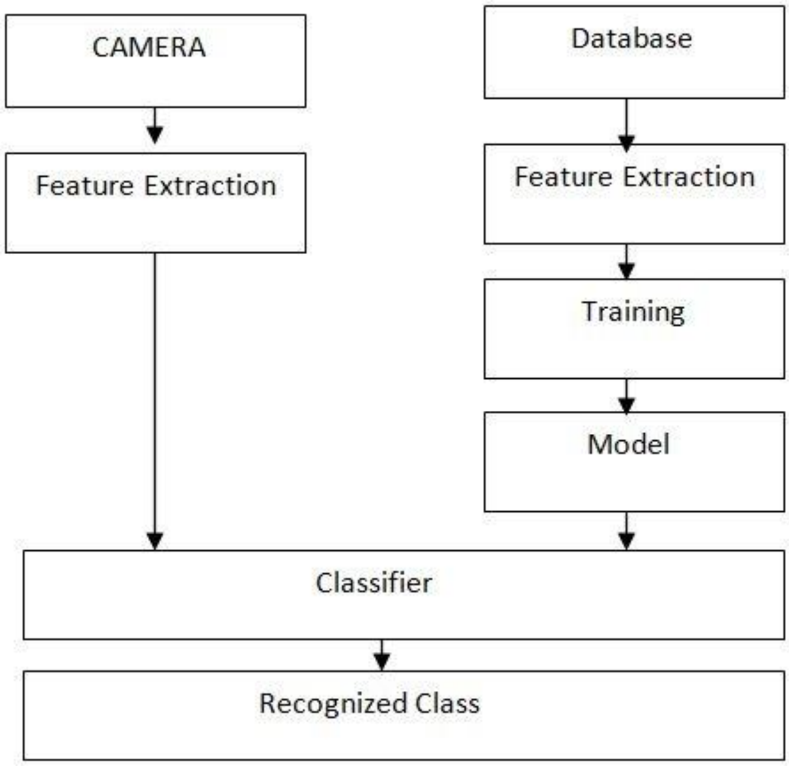

Fig. 3.7 Flowchart of Fruit Detection and Quality Recognition Using CNN

3.3.1 CNN Operation:

In this section, a novel approach to fruit detection using deep convolutional neural networks. The task of fruit detection using image obtained from two modules: color (RGB) and Near-Infrared (NIR). Methodology Fruit segmentation is an important step in order to distinguish the fruits from the background. This section, describes the DCNN approach, Faster R-CNN, which forms the basis of our proposed method Fruit Detection using a Conditional Random. The CRF uses both color and texture features. The color features are constructed by directly converting the RGB values to the HSV color space. Visual texture features are extracted from the NIR channel. NIR images are used to calculate texture features. Three sets of visual texture features are used: (i) Sparse Auto-encoder (SAE) features (ii) Local Binary Pattern (LBP) and (iii) a Histogram of Gradients (HOG).

Each feature captures a different property, such as the distribution of the local gradient, edges and texture, respectively. It uses Faster R-CNN using deep convolutional neural networks on large-scale image classification and detection. Fine-tuning consists of updating, or adapting, the model parameters using the new data. Late fusion combines the classification decisions from the two model. The VGG network is modified and adapted to receive RGB and NIR information simultaneously.

Fig. 3.8: Region of Interest of Images

The convolutional neural networks are applied to utilize the region of interest. This operator applied to each image, the operator takes nine pixels and compares a pixel (the center pixel) to its eight neighbor pixels. The comparison returns 1 when it finds a higher pixel value than the center pixel value otherwise it returns 0 to other neighbor pixels. This procedure is applied to all 8 neighbors. The CNN derived 8 values which is binary values. The comparison is then formed an 8-bit binary number, by merging the resulting values of the comparison together. The formed 8-bit binary number can translate into a decimal value, which is called the value of pixel CNN, the values range in between 0-255. The operation is shown in (Fig. 9). This operation is performed for every pixel for each region of interest.

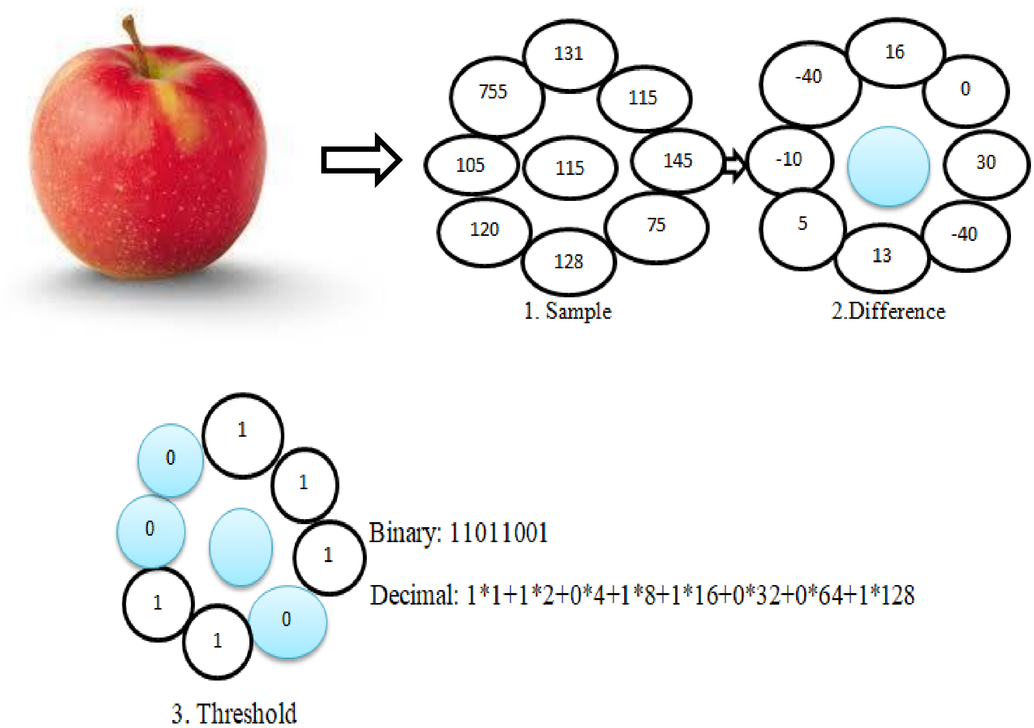

Fig. 3.9: Operations of CNN

Chapter 4

Experimental Analysis

In this chapter, the experiments of the dataset which is used for three different algorithms are conveyed and discussed. In the next section, the results are discussed and the potential conclusions are drawn of the dataset, for the three different algorithms.

4.1 Dataset

In this section we describe how the data set was created and what it contains. we develop a new method to inspect fruit skin defects, which is more accurate, more robust to color noise, and has reduced calculation cost. Packinghouses can adopt this system to distinguish damaged fruits from good ones before packing them into batched, therefore the quality of the products can be guaranteed in this stage. The features of the algorithm in this paper are: (1) the color histogram extracted in the local image patch makes the algorithm more robust to color noise in the orange skin; (2) the Fisher-LDA used for the vector dimension reduction decreases the time cost and makes the algorithm more accurate; (3) the Linear SVM is used for machine learning, which provides higher accuracy and more modest calculation cost.

However due to the variations in the lighting conditions, the background was not uniform and we wrote a dedicated algorithm which extract the fruit from the image. This algorithm is of flood fill type: we start from each edge of the image and we mark all pixels there, then we mark all pixels found in the neighborhood of the already marked pixels for which the distance between colors is less than a prescribed value. we repeat the previous step until no more pixels can be marked. All marked pixels are considered as being image and the rest of pixels are considered as belonging to the object. The maximum value for the distance between 2 neighbor pixels is a parameter of the algorithm and is set (by trial and error) for each dataset. Fruits were scaled to fit a 100x100 pixels image. Our future plan is to work with even larger images, but this will require much more longer training times. To understand the complexity of background-removal process we have depicted a fruit with its original background and after the background was removed and the fruit was scaled down to 100 x 100 pixels. The resulted dataset has 600 images of fruits. Each image contains a single fruit. Separately, the dataset contains another 600 images of multiple fruits.

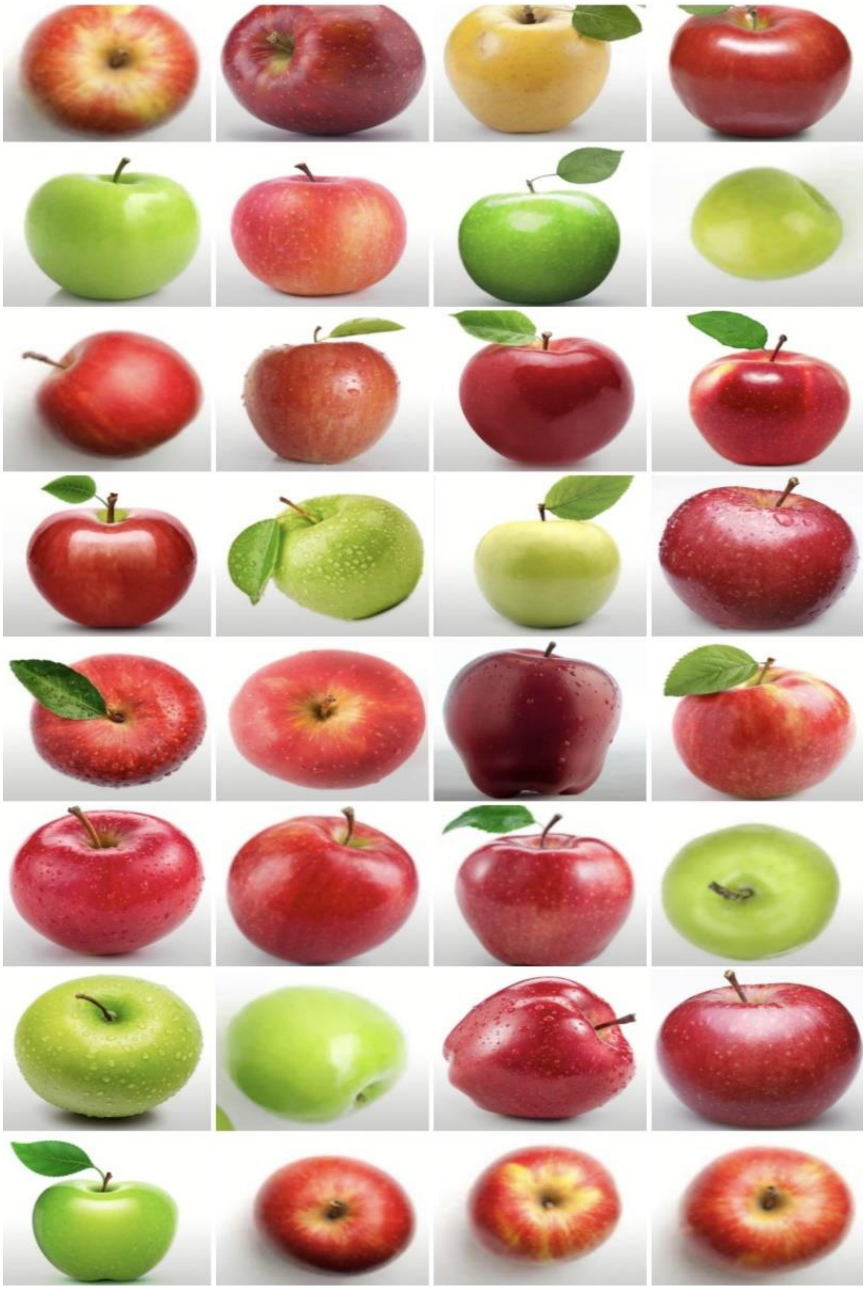

Fig. 4.1: Training database for Fruit Detection and Quality Recognition

4.2 Results

In this section, the experimental results of the implementation are presented. We have already discussed the program works in the methodology sections. In this section, we have provided the details about the results obtained by us while using this program against some of the test cases. We have explained the output of each and every test case using the screenshots of the output provided by our program. While making this project, we faced a lot of challenges and we have tried to minimize it as much as possible of these problems. We evaluated the proposed algorithm on the real-time video frame using Support Vector Machine (SVM). We can see the input fruit images used to create databases for fruit detection and quality recognition are given above.

4.2.1 The Result of CNN Algorithm

In this section, the experimental results of the implementation are presented. We have already discussed the program works in the methodology sections. In this section, we have provided the details about the results obtained by us while using this program against some of the test cases. We have explained the output of each and every test case using the screenshots of the output provided by our program. While making this project, we faced a lot of challenges and we have tried to minimize it as much as possible of these problems.

As mentioned above, we used our own created database. The database consisted of total 600 images that are 3 different fruits for identifying detection of the fruit. The average feature vector for each expression was extracted then the system was loaded by the extracted feature. To identify a fresh and rotten fruit, we performed our experiments fruit detection and quality recognition based on the above-mentioned CNN algorithm. In the proposed algorithm, different types of fruits images have been recognized. Based on the algorithm, the fruit image of unknown fresh and rotten is compared with different type of fruit images of known from a large database. During testing, we recognize the fruit detection for which there exists a weighted combination of basis images that is the closest to the test fruit image. In Fig. 4.2 we can see the input different type of fruit images used to create databases for fruit detection and quality recognition are given below:

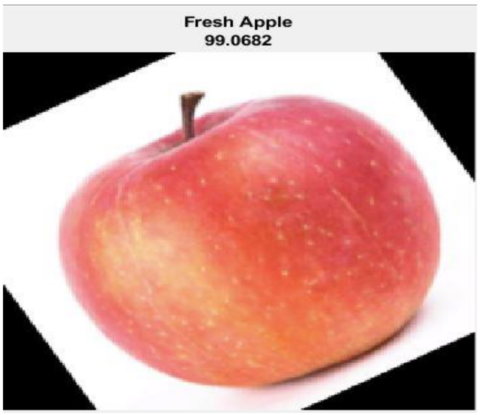

Fig. 4.2: Fruit Quality Recognition Using CNN

4.2.2 Result of TensorFlow

Although the working procedure is same for the three algorithms, but the accuracy rates are not same. There are some limitations of TensorFlow such as, all the images must have the same size. And we should avoid low light areas for capturing images. The TensorFlow method gave about 92% of average accuracy. In Fig. 4.3 we can see the input different type of fruit images used to create databases for fruit detection and quality recognition are given below:

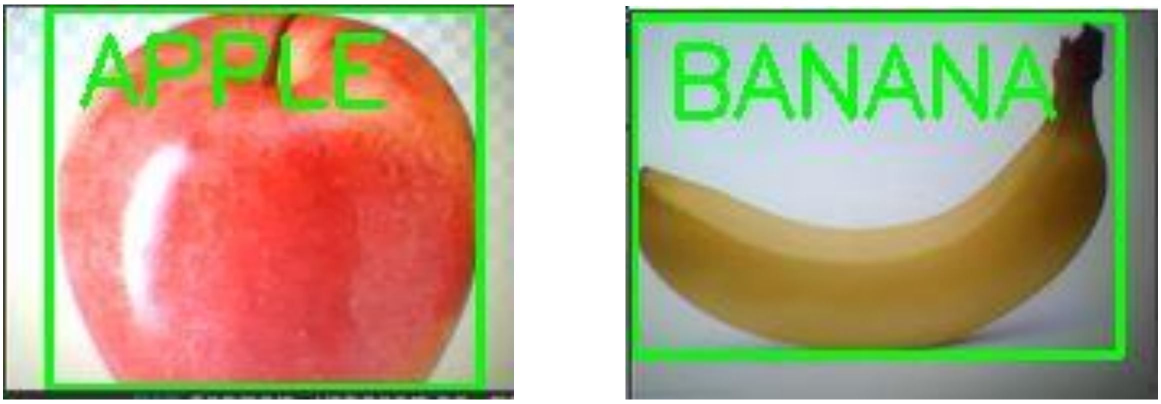

Fig. 4.3: Fruit Quality Recognition Using TensorFlow

4.2.3 Result of SVM

It has the same limitations like CNN. And the algorithm gave about 97% of average accuracy. In Fig. 4.4 we can see the input different type of fruit images used to create databases for fruit detection and quality recognition are given below:

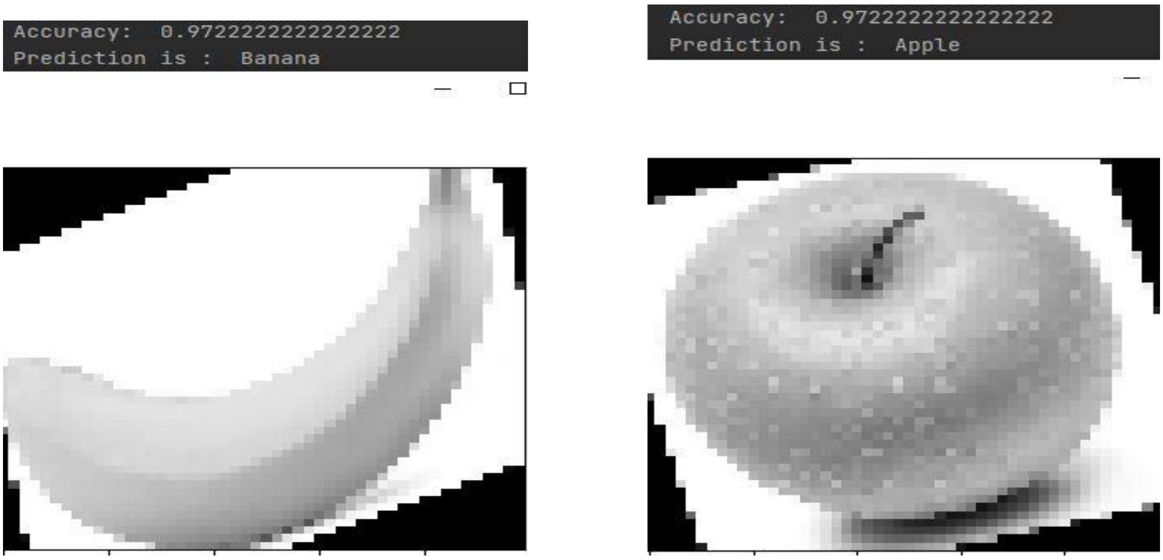

Fig. 4.4: Fruit Quality Recognition Using SVM

4.2.4 Comparison of CNN, TensorFlow and SVM Result

From the overall experiment, we can see that CNN gave about 99% accuracy on average for fruit detection and quality recognition. Where SVM gave about 56% accuracy on average and TensorFlow gave about 55% accuracy. So, it is clear that CNN gave better accurate result than SVM and TensorFlow.

Algorithm	No. of Training data	No. of Testing data	Accuracy (%)
CNN	400	200	99%
SVM	400	200	97%
TensorFlow	400	200	92%

Table 4.2: Dataset and accuracy for Three Algorithms

The above tables show the experimental difference between CNN, SVM and TensorFlow in different cases.

Chapter 5

Discussion

If the input tree image contains one or more fruit regions, the proposed method efficiently detects the fruits. As the color features of the fruit region in the tree image are different than the background, the proposed method gives good result of detection. If the input image is very complex and do not contain a different color fruit, the proposed method fails to extract the fruit regions which is shown in last row of the simulation results of the proposed method. We have developed image processing technique using multiple features for fruit detection. The proposed technique is robust under complex and clustered background. The Fig 4 shows the comparison of different binary map using individual intensity, color, edge and orientation features versus integrated feature map. The binary map generated using only intensity detects the half region of fruit while detecting some background also. Similarly, if we consider only orientation feature than some part of the object is not detected in the final image. So, the feature points are integrated according to their weights for generating more efficient binary map for fruit detection. The efficiency of the fruit detection algorithm depends on the features and their weights calculated for an input image.

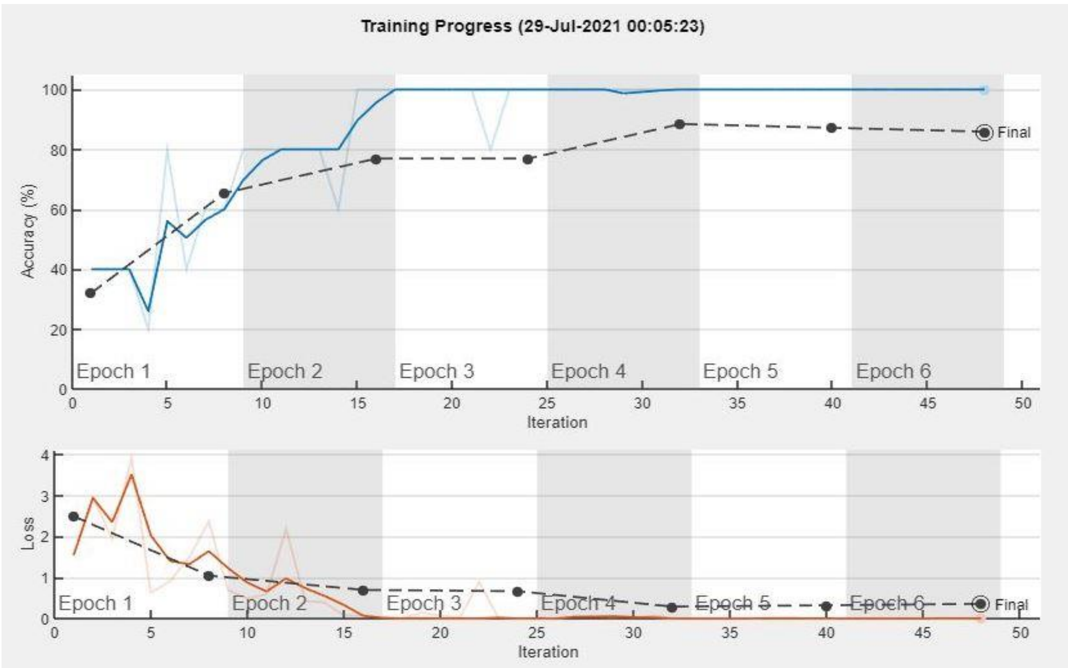

Fig. 5.1: Graph for fruit detection and quality recognition using CNN

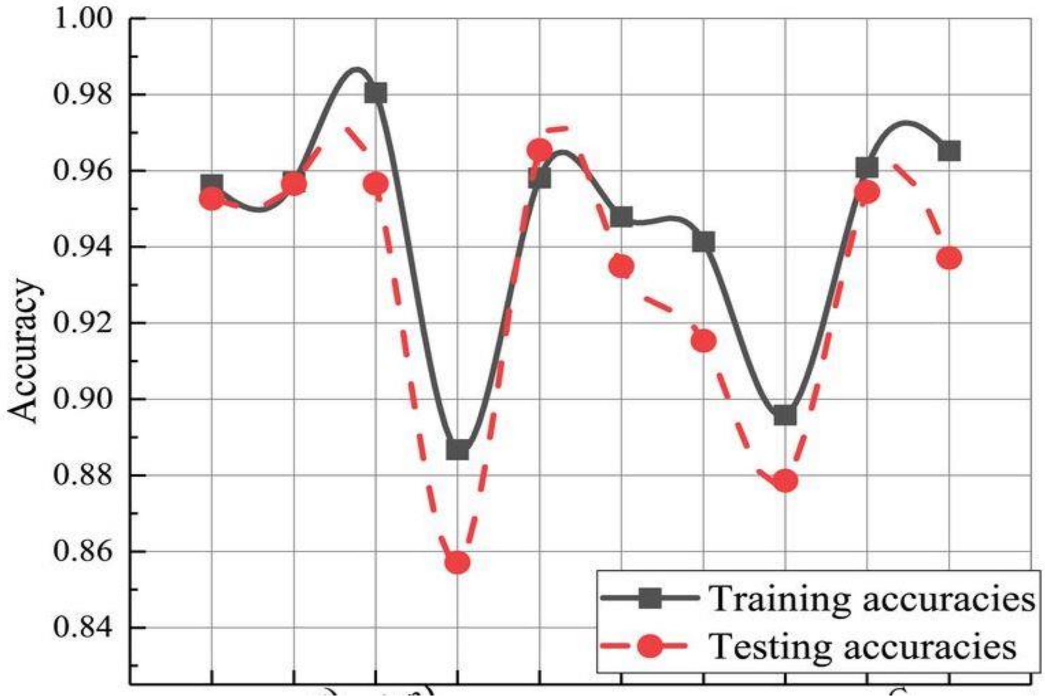

Fig. 5.2: Graph for fruit detection and quality recognition using SVM

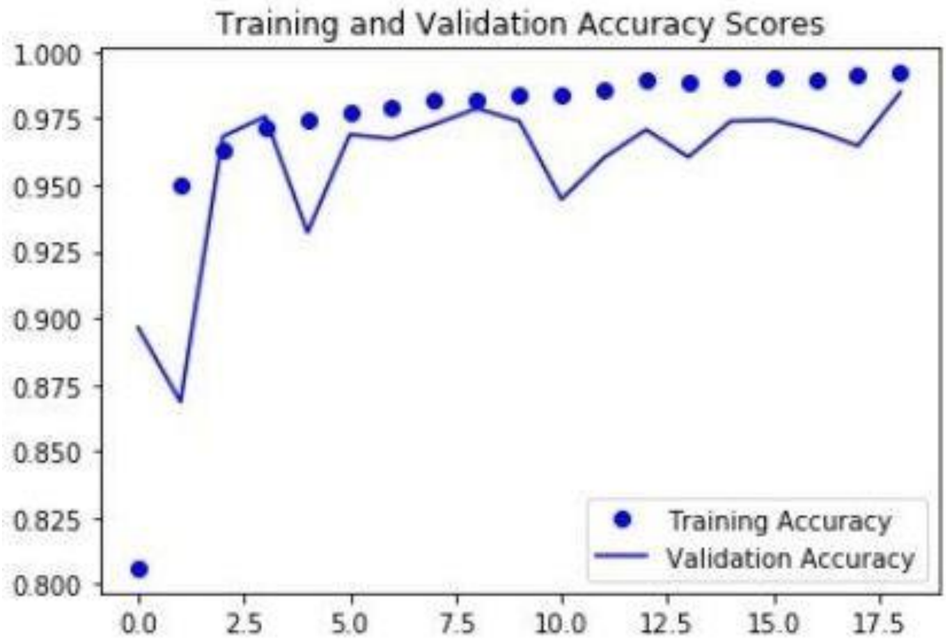

Fig. 5.3: Graph for fruit detection and quality recognition using TensorFlow

Chapter 6

Conclusion

Efficient fruit detection using multiple feature-based algorithm is developed and proposed in this paper. Multiple features like intensity, color, edge and orientation are analyzed. It computes the feature map for different type of feature points and according to the feature map the fruit regions are extracted. The process is entirely automatic and does not need user intervention. The proposed method is not domain-specific and does not impose limits on the variety of clustered sectional tree image. It can be used for all kind of images provided that there are at least one or more meaningful fruit regions. A simple feature cannot entirely represent the character of the fruit region. Therefore, multiple features analysis is used in the proposed method. We described a new and complex database of images with fruits. Also, we made some numerical experiments by using Support Vector Machine (SVM) in order to classify the images according to their content. From our point of view one of the main objectives for the future is to improve the accuracy of the neural network. This involves further experimenting with the structure of the network. Various tweaks and changes to any layers as well as the introduction of new layers can provide completely different results. Another option is to replace all layers with convolutional layers. This has been shown to provide some improvement over the networks that have fully connected layers in their structure. A consequence of 26 replacing all layers with convolutional ones is that there will be an increase in the number of parameters for the network [30]. Another possibility is to replace the rectified linear units with exponential linear units. According to paper [8], this reduces computational complexity and add significantly better generalization performance than rectified linear units on networks with more than 5 layers. We would like to try out these practices and also to try to find new configurations that provide interesting results.

6.1 Limitations

Recognition task takes more time to train a dataset with a large number of images and it is memory consuming. Getting high accuracy is not possible for images with low light. The machine needs to be very well configured for training and testing data. The proposed methodology is limited to classify frontal image only. We have observed improvement areas like the iteration involved in testing images one by one. Since the testing process is independent for each test image, that takes too much time.

6.2 Future Work

In the near future we plan to create a mobile application which takes pictures of fruits and labels them accordingly. Another objective is to expand the data set to include more fruits.

This is a more time-consuming process since we want to include items that were not used in most others related papers.

Future research can be done in optimizing the process of extracting feature points which is a critical step of fruit detection and quality recognition task. In this paper, authors consider colors, intensity, edge and orientations as the features of the image. However, it is very likely that there are some other features such as symmetry features also should be considered. What features and how many features should be extracted according to the target will also be included in the future work. Fruit detection using other imaging devices other than the usual RGB camera will also be investigated in the future work.

References

[1] S.V. Phakade, “Automatic Fruit Defect Detection Using HSV and RGB Color Space Model”, International Journal of Innovative Research in Computer Science & Technology, Vol.2, Issue.3, pp.67-73, May 2014

[2] Cesar G. Pachón-Suescún, Javier O. Pinzón-Arenas, Robinson Jiménez-Moreno, “Fruit Identification and Quality Detection by Means of DAG-CNN” International Journal on Advanced Science Engineering and Information Technology 10(5):2183-2188, October 2020.

[3] Horea Muresan and Mihai Oltean, “Fruit recognition from images using deep learning,” Acta Univ. Sapientiae, Informatica, 10, 1 (2018) 26–42.

[4] Hetal N. Patel, Dr. R.K. Jain and Dr. M.V. Joshi, “Fruit Detection using Improved Multiple Features based Algorithm,” International Journal of Computer Applications (0975 – 8887). Communication, pp. 188-193, 1993.

[5] Yogesh1, Ashwani Kumar Dubey, Rajeev Ratan and Alvaro Rocha, "Computer vision-based analysis and detection of defects in fruits causes due to nutrients deficiency," 11 September 2019 / Revised: 25 November 2019 / Accepted: 8 December 2019 Springer Science Business Media, LLC, part of Springer Nature 2019.

[6] Dr. A. N. Jayanthi, C. Naresh Kumar, S. Rajesh, S. Sathish Kumar, K. Vazhagurunathan “Implementation of Fruit Quality Inspection System Using Image Processing” APR 2019 | IRE Journals | CCCA – 2019 | Volume 2 Issue 10 | ISSN: 2456-8880

[7] Ashwani Kumar Dubey, “Fruit Defect Detection Using Speeded Up Robust Feature Technique”, 5th International Conference on Reliability, Infocom Technologies and Optimization (ICRITO), pp.590-594, 2016