St. Mary's University

Faculty of Informatics

Department of Computer Science

Haricot Bean Grade Classification Using Digital Image Processing

A Thesis Submitted to the School of Graduate Studies of St. Mary's University in Partial Fulfillment for the Degree of Master of Science in Computer Science

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This thesis prepared by **Maereg Teferi**, entitled: Haricot Bean grade classification by using Digital Image Processing and submitted in partial fulfillment of the requirements for the Degree of Master of Science in Computer Science complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Abstract

Most agriculture products are main source of food and industries input, that have big contribution on human being day to day life activities. From most known agricultural products, haricot beans are popular and know edible leguminous product. In Ethiopian, this leguminous bean is the way to get income currency for growth of the country. It takes 15-21 % of market exchange in Ethiopian Commodity Exchanges organization. Haricot beans product need classification based on the level of its quality. Nowadays, the process of identifying quality of haricot is done manually by general inspection and just by looking using naked eye. This process takes much more extra amount of time and the quality measurement has low accuracy because, it is subjective and depends on the condition of the person doing the tasks. As a result of which, controlling the quality of haricot beans is not effective and efficient. To solve this major problem the current study proposes haricot bean grade classification by using digital image processing.

Digital Image processing technology is an emerging and growing technology to resolve this kind of practical and physical problem. Each level of the research was held by using experimental method. As experimental tool, we have used MATLAB software. For the experiment, the researcher collect sample haricot beans from ECX laboratory and then capture with image quality of 3264 by 2448 pixels. The captured images have some noises that appear from camera and environmental setting. To remove this noise media filtering technique is applied. After the binirized images were segmented by watershed segmentation techniques, convolutional neural network is employed as feature extractor and classifiers. The researcher used *Add-16* feature extractor algorithm from ResNet-50 package. To train the classifier we have used 300 training image set and 90 individual test set. Experimental result shows that the model achieves 90.0% grade classification of haricot bean, which is a promising result. After all, classification algorithm have error of 10% of from individual test. So the researcher recommend that to minimize the rate of error happen in classification.

Key words: Haricot Bean; Grade Classification; Digital Image Processing; CNN; Resnet50

Dedicated To

My mom(Alemitu Seife),My dad (Teferi Demeke),My wife (Fasika Shumet)

My sister (Rut Teferi)

And

To my beloved and new born Son Natania Maereg

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Acronyms

- ✓ DNA-Deoxyribose Nucleic Acid
- ✓ ECX-Ethiopian Commodity Exchange
- ✓ K-NN – k Nearest Neighbor
- ✓ RGB- Red, Green and Blue color model
- ✓ LG – Lower Grade
- ✓ BW- Black and White
- ✓ OpenCV- Open Source Computer Vision Library

Chapter One

Introduction

1.1. Background

Haricot beans are an important pulse crop in Ethiopia and in the world. The crop ranks first globally while it stands second next to faba bean in the country [1]. The major haricot beans producing regions include Oromia, Amhara and Southern Nations Nationalities and Peoples (SNNPR) [1] with their share to the national haricot bean production of 51%, 24 % and 21% respectively. Haricot bean is the most important pulse crop in the SNNPR. It is grown both as sole crop and in association with other crops. Though it is produced in most parts of the southern region, the leading zones of production are Sidama, Wolayita and Gamo Gofa [2]. The nutritional composition of haricot bean contributes greatly towards a balanced and healthy diet. This is because of the grain has high protein content and good micro-nutrient concentration. Some people say it is considered as 'a poor man's meat' because of its high protein content. Moreover, their amino acid composition is useful to complement the amino acid profile of cereal proteins. Thus, haricot bean is an important crop in addressing the issue of nutrition security in southern Ethiopia where people's diet is dominated with maize, root and tube crops [2].

According to ECX (http://www.ecx.com.et) trade systems are done by man power in different aspects. This leads to more error prone and that not much enough to support modernize exchanges on all commodity. This future leads to the need for technological support to have greater success. ECX looks different opportunities to make it more reliable and accurate in many directions. Image processing is a method to design an application using image taken from real time acquisitions [3]. Nowadays, image processing is among rapidly growing technologies that can be used with machine learning algorithms to analyze digitized images for solving problems with less human intervention. Digital image is an array of real processing that gives improved pictorial information for human interpretation and processing of image data for storage, transmission, and representation for machine perception [3]. Modern digital technology has made it possible to manipulate multi-dimensional signals with systems that range from simple digital circuits to advanced parallel

Computer applications [3]. In this study image processing is employed along with machine learning algorithm to justify the final result for haricot bean quality detection and classification [4]**.**

Image may be defined as a two-dimensional function, f(x, y), where x and y are spatial (plane) coordinates, and the amplitude of *f* at any pair of coordinates (x, y) which is called the intensity or gray level of the image at that point [5]. When x, y, and the amplitude values of f are all finite, discrete quantities, we call the image a digital image. The field of digital image processing refers to processing digital images by means of a digital computer. [5].In image processing the basic steps are image preprocessing, image analysis, and image understanding.

Image pre-processing methods are intended for image improvement for the needs of next processing of the image (generally object recognition) [6]. The main goal of pre-processing is noise suppression (usually the origin of the noise is digitizing and transmission), removal of distortion given by the scanning device, eventually suppress or highlight other attribute, which are important for following processing, segmentation and edge detection [6]. Basic pixel position independent operations with images are grey scale transformation, brightness correction and gamma correction. Very important part of every image processing software is Histogram Equalization. It improve contrast and the goal of histogram equalization is to obtain a uniform histogram. The operation can be applied to whole image or just to a part of an image [6].

There is a specific group of transformation called filtration, which transfer values of brightness of input image to other values of brightness in purpose of highlight or suppress some properties of image. Often is realized image smoothing, thus suppression of high frequencies of image [6]. The most used types of filters for the set application area are: filtering by the common averaging, median filters, filtering by the gliding averaging, filtering by the Gauss filter, filtering by means of Fourier transform [6].

Image analysis refers usually to processing of images by computer with the goal of finding what objects are present in the image. More specifically, given an image, we wish to outline all objects present in it and provide at least a rough description of their surfaces [7]. This task can be performed easily by a person, but machines find it nearly impossible. Part of the reason is the vagueness of the term object [7] . It is an intuitive term and therefore not very useful for designing algorithms. While it is clear what a physical object is, it is less clear what an object in a picture is. The computational analysis of images is challenging as it usually involves tasks such as segmentation, extraction of representative features, matching, alignment, and tracking. In the analysis of the objects in images it is essential that we can distinguish between the objects of interest and the rest. This latter group is also referred to as the background [8]. The techniques that are used to find the objects of interest are usually referred to as segmentation techniques, segmenting the foreground from background. It is important to note that image analysis is part of a wider field known as image processing, where the main underlying idea is to improve the visual quality of an image and/or to extract useful information or features. The analysis is based on different image properties such as color, gloss, morphology of the objects, and texture [8].

Image understanding means describing the image content, the objects in it, location and relations between objects, and most recently, describing the events in an image. Machine vision systems construct internal models of the processed scene, verify them, and update them, and an appropriate sequence of processing steps must be performed to fulfil the given task. If the constructed internal model matches the reality, image understanding is achieved [9].

There are different application areas of image processing and machine learning algorithms like the quality analysis, classification and identification of defects of coffee, rice and beans [3] [10] [11]. Methods and techniques of external grading systems for agricultural crops quality inspection recommended by [11]**,** the researcher attempt to apply image processing task mixed with machine learning algorithms. In some areas analysis of rice granules using image processing and neural network is described [12]. Other researchers like [11] combine the image processing and neural network for classification system for beans using computer vision system and artificial neural networks. The result of this research has a great contribution on grade classification of haricot beans for removing subjectivities and human errors.

Quality and grade classification agricultural product were done by ruled based grade classification like [13] and [14] on sesame grading and quality of maize respectively. On those research method there were problem on classification by using fixed type of feature extraction. That mean, the statically feature extraction restricted on size, shape, texture, perimeter and related measurement. But in this research, those all characteristic consider as small representation. Number of feature were extracted by CNN. All the rule based tasks were become dynamic and it take thousands and hundred thousand feature and its layers. The classifier were depend on those feature extracted by it. So, our work focus on combining segmentation algorithm and use number of feature layer to classify the product. And also it take small execution time better accuracy and promising result comparing with rule based models.

1.2. Statement of the Problem

As experts of ECX noted, the conventional process of identifying quality of haricot is by general inspection and just by looking using naked eye. This process consume huge amount of time and has low accuracy because, it is subjective and depends on the condition of the person doing the tasks. As a matter of fact, the effectiveness of manpower to control the quality is that much not effective as well as inefficient, error prone and inconsistent.

In addition to this, there are researches done on maize and sesames grain by Daniel Haile Michael in 2015 and Hiwot Desta in 2017 respectively, both of the researcher works with rule based classification and grading. Technology aid system brings good quality control and evaluation to get better price for country and traders who supply the product. So it is a must to automate quality control and grade classification of agricultural products by applying image processing.

Even though, Haricot beans have high rate of exchange value next to coffee in Ethiopia ECX, many researchers have done researches on haricot beans production rate [1] assessments of growth, production and market issues [15] are done but there is no research on the haricot bean grade classification by using digital image processing. However the use of image processing technology enables to automate grade classification problems of haricot beans. This study therefore enables to apply image processing with machine learning to design a model for grade classification of Haricot Bean.

To this end, the current study attempt to explore and answer the following research questions.

- ✓ What are the suitable image processing techniques to use for image filtering, segmentation and feature extraction?
- ✓ What suitable classification algorithm to apply for constructing a model for grade classification of haricot bean?

- ✓ To what extent the prototype works in haricot beans quality assessment and classification?

1.3. Objective of the Study

1.3.1. General Objective

The main objective of this research is to design a model for classifying grade of haricot beans by using digital image processing.

1.3.2. Specific Objectives

Specifically to achieve the general objective, the following specific objectives are formulated.

- To review literatures and related work done on different agricultural products, digital image processing and machine learning algorithms.
- To capture and prepare sample haricot beans images representing different features
- To identify and select the best features of haricot beans that suits to represent grades of haricot beans.
- To apply image filtering, segmentation, and feature extraction algorithms for constructing classification model.
- To develop a prototype and evaluate the effectiveness of the prototype in grade classification.
- To develop a prototype which have the capacity of grading haricot bean product.
- To evaluate the effectiveness of the prototype in grade classification.
- To report the finding and recommend the future work.

1.4. Methodology of the Study

Technology came quite useful for the investigators in this field and Computer Vision Systems have develop for quality control and will start to use as an objective measurement and evaluation system mainly from camera to computer. The haricot bean grading is performed by using digital image processing techniques and machine learning algorithm. Image processing tools are used to process Digital image and extract features, which is an input for machine learning algorithms that help to predict the grade of haricot bean. Finally the researcher tests the performance of the system with related systems issues and researches result.

1.4.1. Research Design

This study follows experimental research method. Experimental research is a study that strictly adheres to a scientific research design. It includes a hypothesis, a variable that can be manipulated by the researcher, and variables that can be measured, calculated and compared [16]. Most importantly, experimental research is completed in a controlled environment. The researcher collects data for experimentation and come up with results as per the objective of the study [16].

The main reason for selecting this method is that both image processing and machine learning algorithms are identified based on experimental results. Experimental researches are more involved on dataset preparation, implementation tool selection and also focus on performance evaluation of the prototype [16].

1.4.2. Data Set Preparation

Any experimental research is highly dependent on dataset. Dataset for this research is a collection of haricot beans images which is collected by charge coupled digital camera having dimension of 3264 X2448 pixels. The captured images are stored in the form of JPEG (joint photographer expertise group) file formats. This file format takes small File size and high resolution when it compared to bitmap and PNG file format [17].

From Ethiopian commodity exchange, the researcher collect white haricot bean sample that were classified based on laboratory which is classified with manual method. Totally we have capture 390 images. Firstly we have capture 25 image in 6 class and totally 150 images of haricot beans but this image can't satisfies both the accuracy of the classification model and the promising result that expect from research experiment. So, we add new 150 image and totally we train the system with 300 image. Additionally the researcher capture 90 image for individual test or validate the exactness of the model performance.

1.4.3. Implementation Tools

In this experimental test, the researcher uses MATLAB version 2019a. MATLAB 2019a is used for implementation and experimentation. Although it was created for manipulating matrices in general, it is well suited to image processing applications. MATLAB treats an image as a matrix, allowing a designer to develop optimized matrix operations implementing an algorithm [18]. However, if the eventual goal is a hardware device, the algorithms are instead often written to operate similarly to the proposed hardware system, which results in an even slower algorithm [18].

MATLAB is used to gain insight into image and video data, develop algorithms, and explore implementation tradeoffs. Mostly MATLAB is used to [18]:

- ✓ Design vision solutions with a comprehensive set of reference-standard algorithms for image processing, computer vision, and deep learning
- ✓ Collaborate with teams using Open CV, Python, and C/C++ using interoperable APIs and integration tools.
- ✓ Use workflow apps to automate common tasks and accelerate algorithm exploration.
- ✓ Accelerate algorithms on NVIDIA GPUs, cloud, and datacenter resources without specialized programming or IT knowledge.
- ✓ Deploy algorithms to embedded devices, including NVIDIA GPUs, Intel processors and FPGAs, and ARM-based embedded processors.

MATLAB have different application and usage in addition to image processing and analysis. Those tasks are signal processing , mathematics and statistics ,data science and deep learning ,system engineering , parallel computing ,real time simulation and testing , control system and application development are basic and main tasks performing by this software [18].

From those application Image Processing Toolbox provides a comprehensive set of reference-standard algorithms and workflow apps for image processing, analysis, visualization, and algorithm development. We can perform image segmentation, image enhancement, noise reduction, geometric transformations, and image registration using deep learning and traditional image processing techniques. The toolbox supports processing of 2D, 3D, and arbitrarily large images [18].

Image Processing Toolbox apps automate common image processing workflows. We can interactively segment image data, compare image registration techniques, and batch-process large datasets. Visualization functions and apps explore images, 3D volumes, and videos; adjust contrast; create histograms; and manipulate regions of interest [18].

1.5. Significance of the Study

In emerging image processing research, each research provide and build model or framework that is used in real world day-to-day human being activities. This research has the following significance for Ethiopian commodity exchange organization, and individuals and organizations engaged in haricot beans production, promotion and distribution.

- ✓ This research overcome the human error and subjective in quality judgment and it will save time wasted by expertise to evaluate the quality.
- ✓ It gives a platform to conduct grading at one specific place, centralization. This in turn will enable ECX the organization to have the same standard across all products and quality control will be easy.
- ✓ It reduce capabilities of decision-making that comes from human inspector physical condition such as fatigue and eyesight, mental state caused by biases and work pressure, and working conditions such as improper lighting, climate.
- ✓ It also builds more capacity than the previous trend in classifying the grade of haricot bean in the laboratory.
- ✓ It provide well prepared haricot bean image dataset for the next researcher, which like to do on recommended research areas.

In this research, the researcher find and justify the way of classifying white haricot bean grade by using single type of product . Now a day organization provide red color haricot bean for world market demand so, we recommend that they try to find for both color and product grade classification. in addition to this other researcher can perform grading and classification of product with combining different out layers and the system will calculate and inform the expertise in which grade the product will be categorize and how much present of the sample are in a given categories

1.6. Scope and Limitation of the Study

The scope of this research is mainly focused on grade classification of haricot beans using digital image processing. The main dataset input for this process are images of haricot beans taken from laboratory test in Ethiopian Commodity Exchange. The image processing techniques used haricot beans image as data source to establish the model for enhancing quality judgment during quality detection. Mainly the way of evaluating and detecting grade of the haricot beans is based on numbers of features generated by the classifier and feature extractor algorithm on the grain exceptionally.

In this research, the researcher follows basic procedure of image processing. The first and most time taking process were collecting and capturing image of haricot beans. Then, the capture images were pass through image pre-processing mechanism, especially median filtering techniques to remove noise that happen on capturing stage. Filtered images changed to binirized form. This binirized image segments with threshold values of 0.5 that we have get threshold value from histogram equalization. Watershed segmentation were used for segmenting the haricot bean image. After all the segmented collection of haricot bean image collect as dataset. The dataset split into 70 % for training and 30% for testing. The researcher test two CNN algorithm for feature extraction and grading system. Those algorithms are a*dd-16* and *fc1000*. On this research we have evaluate the classifier algorithm by comparing the deep classification layer and the execution time to response the exact result (grade) of haricot bean. Those CNN algorithm packages are ResNet18, ResNet50 and desnet201 are compare each other. Finally the researcher Select CNN classifier which is ResNet-50 classification algorithm for grade classification of the product. This study have the limitation of defining and classing haricot bean with different out layers and mixed materials. Other type of haricot bean product are available on market but the model classifies only white color haricot beans only.

1.7. Organization of the research

The remaining of this thesis report is organized as follows. In Chapter 2, the literature review will be presented in brief and discusses related works that had been carried out on automatic classification and grading of agricultural products. The proposed architecture and design of haricot bean grade classification is presented in Chapter 3. The experiment, test results and discussion are presented in Chapter 4. In Chapter 5, conclusions, contribution of the thesis will be drawn and future works will be pointed out.

Chapter Two

Literature Review

2.1. Overview

In this chapter there are three basic parts were included. On the first part, the researcher try to include the review on haricot bean nature, production, food content relatively others food content. The second part of this chapter were review on the basic image processing step and procedure, application area, task of image processing like (preprocessing, segmentation ,feature extraction and classification)were included. The third and the last part of this chapter were related work with our research and the gap that observed were included on researcher.

Haricot bean (*Phaseolus vulgaris* L.) belongs to the legume family (Leguminosae) [19]. It is widely cultivated and represented in one of the largest food components in Latin America and Africa valued for its high content of protein and micronutrients such as iron and folic acid [19]. It is one of the most economically important crops in Latin America and source of income for small farmers [19]. Beans are considered a warm-season crop, sensitive to temperature extremes. Low temperatures slow down plant growth while high temperatures accelerate it. Generally, plants are more adaptive during short days; they are very frost tender and need a minimum average soil temperature (18°C) to germinate well [19]. Most types of bean require a frost-free growing season of 85 to 120 days [19].Accordingly the nutrition composition relative to maize is that has high contents mainly carbohydrate, protein, fat, fiber and mineral having 57.8% ,22.9% ,1.6% ,4.0% and 3.6% respectively and the rest of the contain is water [2].

Haricot bean (especially white pea bean and red kidney bean) is highly exported to the overseas market. The Ethiopian Commodity Exchange was started to benefit and modernize, the way Ethiopia was trading its most valuable assets and its commodities. Ethiopia needs a change from the traditional means of trading to better support the needs of all those involved in the trading and production [20].

According to ECX official website (http://www.ecx.com.et),the market participants in Haricot beans trade include producers, wholesalers, retailers, part-time farmer- traders, brokers, agents, assemblers, processors, cooperatives, and consumers. In ECX exchange is held on different agricultural product mostly collected from farmers in different countryside districts. Most of the time products are coffee, soya, chickpea wheat, maize, haricot beans, kidney sesame and some related spices. There is a wide range of haricot beans types grown in Ethiopia including mottled, red, white and black varieties. The most commercial varieties are pure red and pure white colored beans and these are the most commonly grown types with increasing market demand all those which is listed are exchange based on the quality that have extracted and evaluated [20].

In this literature review and related works, we try to include the concept of digital image processing, how the process works and application area in real world. In addition to this we have include the related work with regard to image processing on agricultural product. In other continents of the world Haricot beans are considers as small, oval, plump and creamy-white with a mild flavor and smooth, buttery texture [1]**.**

In US, they are known as navy beans and are classic ingredient in Boston baked beans [21]. Haricot beans are widely used in different countries such as France, Spain, Portugal and South America. With little flavor of their own, they absorb other aromas and flavors easily, which makes them popular beans to use in bean salads, vegetable soups, slow-cooked dishes such as bean purées [21]. Haricot bean (especially white pea bean and red kidney bean) is highly exported to the overseas market. The Ethiopian Commodity Exchange was started to benefit and modernize, the way Ethiopia was trading its most valuable assets and its commodities. Ethiopia needs a change from the traditional means of trading to better support the needs of all those involved in the trading and production [20].

2.2. Digital image processing

Digital image processing consists of the manipulation of images using digital computers. Its use has been increasing exponentially in the last decades with applications range from medicine to entertainment, passing by geological processing and remote sensing [22] Multimedia systems, one of the pillars of the modern information society, rely heavily on digital image processing.

The discipline of digital image processing is a vast one, encompassing digital signal processing techniques as well as techniques that are specific to images. An image can be regarded as a function $f(x, y)$ of two continuous variables x and y. To be processed digitally, it has to be sampled and transformed into a matrix of numbers. Since a computer represents the numbers using finite precision, these numbers have to be quantized to be represented digitally. Digital image processing consists of the manipulation of those finite precision numbers [23].

An image can be defined as a 2-D function f(x, y) where (x, y) is co-ordinate in two dimensional space and f is the intensity of that co-ordinate [22]. Each co-ordinate position is called as pixel. Pixel is the smallest unit of the image it is also called as picture element or pixel. So digital images are composed of pixels, each pixel represents the color (gray level for black and white images) at a single point in the image.

Digital image processing is a very popular and rapidly growing area of application under computer science and engineering [24]. Its growth leads by technological innovations in the fields of digital imaging, computer processing and mass storage devices. Fields which have been traditionally using analog imaging are now switching to digital systems, for their editablity and affordability. Important examples are medicine, and video production, photography, remote sensing, and security monitoring [24]. These sources produce a very huge volume of digital image data daily, more than could ever be examined manually. Basically image processing can be defined as the processing of a two dimensional picture by a computer. The outcome of image processing could be an image or a result as set of features or characteristics related to the image. Most image processing methods treats an image as a two dimensional signal and implementing standard signal processing techniques to it [24].

The goal of digital image processing operations can be divided into three major categories [25, 23].

- ✓ Firstly image preprocessing in which input is an image and output is also an image but with better quality ready for image analysis;
- ✓ Secondly image analysis in which input is an image and output are the dimensions or measurements.
- ✓ Finally image understanding in which input is measurement and description of an image and the output is verification, identification and recognition of an image is an image and output is the standard description of an image.

Some of the important applications of image processing in the field of science and technology include computer vision, remote sensing, feature extraction, face detection, forecasting, optical character recognition, finger-print detection, optical sorting, argument reality, microscope imaging, lane departure caution system, Non-photorealistic representation, medical image processing, and morphological imaging [23].

Digital image processing has become economical in many fields like signature recognition, iris recognition and face recognition, in forensics, in automobile detection and in military applications. Each of these applications has its basic requirements, which may be unique from the others [23].

2.3. Tasks of Image processing

Use the image processing built-in functions for transforming, manipulating, and analyzing images, image transformation and manipulation. From basics processing events, image processing have different task in day today activity on the world. Mostly remote sensing image sharpening and restoration machine vision and rebooting task ,medical fields, video processing ,image recognition and classification ,color processing and microscopic imaging ,transmission and encoding [26].

Image sharpening and restoration refers here to process images that have been captured by the modern camera to make them a better image or to manipulate those images in way to achieve desired result. It refers to do what Photoshop usually does. This includes Zooming, blurring, sharpening, gray scale to color conversion, detecting edges and vice versa, Image retrieval and Image recognition. The quality of the video depends on the number of frames/pictures per minute and the quality of each frame being used [26]. Video processing involves noise reduction, detail enhancement, motion detection, frame rate conversion, aspect ratio conversion, color space conversion. Field of remote sensing the area of the earth is scanned by a satellite or from a very high ground and then it is analyzed to obtain information about it. One particular application of digital image processing in the field of remote sensing is to detect infrastructure damages caused by an earthquake [26].

2.3.1. Image Acquisition

It is the first step or fundamental step of digital image processing. Under image acquisition the image is given in digital format. Generally, image acquisition involves preprocessing, such as image enhancement and noise filtering. An image can be made input by some sort of scanner, digital cameras or with the help of aerial cameras [23].This image should be a high quality image with greater resolution, which helps in proper image analysis.

The images are generated by combination of an illumination source and the reflection or absorption of the energy by the elements of scene being imaged [27]. Illumination may be originated by radar, infrared energy source, computer generated energy pattern, ultrasound energy source, X-ray energy source etc. To sense the image, we use sensor according to the nature of illumination [27]. The process of image sense is called image acquisition. By the sensor, basically illumination energy is transformed into digital image [27]. The idea is that incoming illumination energy is transformed into voltage by the combination of input electrical energy and sensor material that is responsive to the particular energy that is being detected. The output waveform is response of sensor and this response is digitalized to obtain digital image. Image is represented by 2-D function f(x, y). Practically an image must be non-zero and finite quantity that is [27].

2.3.2. Image Preprocessing

Image preprocessing is the process of enhancing and removing noise which is created in capturing environment. This process help to improve the capacity image classification algorithms. In this process removing noise and enhancement are the tasks perform in preprocessing [28]. Some preprocessing operations are required to be performed on the input image. The aim of preprocessing techniques is to improve the image data to suppress the unwanted distortions and to enhance some features of the input image [23].

The processing of digital images can be divided into several classes [5]: image enhancement, image restoration, image analysis, and image compression. In image enhancement, an image is manipulated, mostly by heuristic techniques, so that a human viewer can extract useful information from it. Image restoration techniques aim at processing corrupted images from which there is a statistical or mathematical description of the degradation so that it can be reverted [23].

When processing high resolution images, the image size is needed to be reduced because of the reason that processing on high resolution images takes a longer time. The color image should be converted into grey scale image, because less information is needed to be provided for each pixel [23].

The formation of an image or its conversion from one form into another or its transmission from one place to another often involves some degradation of image quality with the result that the image then requires subsequent improvement, enhancement or restoration. Image restoration is commonly defined as the reconstruction estimation of an image to correct for image degradation and approximate and ideal degradation free image as closely as possible [29]. Image enhancement involves operations that improve the appearance of an image to a human viewer or convert an image to a format better suited to machine processing [29].

There are basically two approaches for image de-nosing; spatial filtering method and transform domain filtering method.

2.3.2.1. Spatial Filtering Method

Spatial filtering is the method of choice in situations when only additive noise is present. It can be further classified into two categories: Linear filters and Non Linear Filters [30].

I. Linear Filters

The mean filter is a simple sliding-window spatial filter that replaces the center value in the window with the average or mean of all the pixel values in the window [31]. The window, or kernel, is usually square but can be any shape. Linear filter includes Mean filter and Wiener filter [30].Mean filter provides smoothness in an image by reducing the intensity variations between the adjacent pixels. Mean filter is essentially an averaging filter. Mean filter is the optimal linear for Gaussian noise in the sense of mean square error. It blurs sharp edges; destroy lines and other fine feature of image. Mean filter calculates the average value of the image with noise in a predefined area and the center pixel intensity value is then changed by average value of pixels in the neighborhood [30]. This process is repeated for all pixel values in the entire image. The main disadvantage is that edge preserving criteria is poor in mean filter.

Wiener filter is the most important technique for removal of blur in images due to linear motion or unfocussed optics is the Wiener filter [30]. From a signal processing point of view, softening due to linear motion in a photograph is the result of poor sampling. Every pixel in a digital representation of the photograph should represent the intensity of a single stationary point in front of camera. Unluckily, if the shutter speed is slow and the camera is in motion, a given pixel will be having an amalgram of intensities from points along the line of the camera's motion [30].

II. Non-Linear Filters

In recent years, a variety of non-linear median type filters such as rank conditioned, relaxed median, weighted median and rank selection have been developed to overcome the shortcoming of linear filter. With the non-linear filter, noise is removed without any attempts to explicitly identify it. It is the method of choice in situations when multiplicative and function based noise is present. In this case, the median of the neighborhood pixels determine the value of an output pixel.

Median filter belongs to the class of nonlinear filter. Median filtering is done by, firstly finding the median value by across the window, and then replacing each entry in the window with the pixel’s median value. Median filter is a best order static, non- linear filter, whose reply is based on the positioning of pixel values on basis of rank contained under the filter region [30]. Median filter yield good result for salt and pepper noise. These filters are primarily smoothers for image processing, as well as in signal processing. The benefit of the median filter over linear filters is that the median filter can remove the effect of input noise values with huge magnitudes [32].

2.3.2.2. Transform Domain Filtering

The transform domain parsing can be divided according to choice of basic functions as Non adaptive transform and adaptive transform [32] . Non-adaptive transform is divided into wavelength domain and spatial frequency domain. Wavelength domain filtering operations in the wavelet domain can be subdivided into linear and nonlinear methods. Linear filters such as Wiener filter in the wavelet domain yield optimal results when the signal corruption can be modeled as a Gaussian process and the accuracy criterion is the mean square error (MSE). However designing a filter based on this assumption frequently results in a parsed image that is more visually displeasing than the original noisy signal, even though the parsing operation successfully lessens the MSE. In a wavelet-domain spatially adaptive wiener filtering for image de-noising is proposed where wiener filtering is performed only within each scale and intra-scale filtering is not allowed.

Wavelet transform is one of the non-linear threshold filtering. The most investigated domain in de-noising using Wavelet Transform is the nonlinear coefficient thresholding based methods. The methods exploit sparsity property of the wavelet transform and the fact that the Wavelet Transform maps white noise in the signal domain to white noise in the transform domain. Thus, while signal energy becomes more intensive into fewer coefficients in the transform domain, noise energy does not. It is thus important principle that enables the separation of signal from noise.

2.3.3. Segmentation

Segmentation is a generic term for those techniques which involve taking an image and extracting information relevant to specific picture Segments, such as lines, regions and objects, and their inter-relationship [29]. It is basically a process of data compression by pixel classification, in that an image is segmented into subsets by assigning individual pixels to particular classes [29]. There are three most common used types of segmentation. Those are region based, clustering based segmentation, Edge based Segmentation [33].

2.3.3.1. Region based segmentation

This method is based on segmenting an image on the basis of similar characteristics of the pixels. Region based segmentation method is further divided into two categories [34]: ***Region growing methods and Threshold Segmentation.***

The region growing based segmentation methods are the methods that segments the image into various regions based on the growing of seeds (initial pixels) [34]. These seeds can be selected manually (based on prior knowledge) or automatically (based on particular application). Then the growing of seeds is controlled by connectivity between pixels and with the help of the prior knowledge of problem, this can be stopped [34].

Threshold segmentation is the simplest method of image segmentation and also one of the most common parallel segmentation methods. It is a common segmentation algorithm which directly divides the image gray scale information processing based on the gray value of different targets

[33]. Threshold segmentation can be divided into local threshold method and global threshold method. The global threshold method divides the image into two regions of the target and the background by a single threshold [33]. The local threshold method needs to select multiple segmentation thresholds and divides the image into multiple target regions and backgrounds by multiple thresholds. The advantage of the threshold method is that the calculation is simple and the operation speed is faster. In particular, when the target and the background have high contrast, the segmentation effect can be obtained [33]. The disadvantage is that it is difficult to obtain accurate results for image segmentation problems where there is no significant gray scale difference or a large overlap of the gray scale values in the image. The various advantages of threshold method are: Simple to implement and Fast (especially if repeating on similar images).

On threshold segmentation Pixels are allocated to categories according to the range of values in which a pixel lies. Threshold segmentation is the simplest method of image segmentation and also one of the most common parallel segmentation methods. It is a common segmentation algorithm which directly divides the image gray scale information processing based on the gray value of different targets. Threshold segmentation can be divided into local threshold method and global threshold method. The global threshold method divides the haricot image into two regions of the target and the background by a single threshold. Global threshold is based on selecting an appropriate threshold value. The threshold haricot image q(x,y) is defined as p(x, y)p(x,y)={1ifundefined(x,y)>T0ifundefined(x,y)≤T. The result of thresholding is a binary image, where pixels with intensity value of 1 correspond to objects, whereas pixels with value 0 correspond to the background. i.e. T. This T is a constant and output image depends upon this T value.

$$q(x,y) = \left\{ \begin{array}{l} 1, \text{ if } p(x,y) > T \\ 0, \text{ if } p(x,y) <= T \end{array} \right\} \qquad \text{------------------------------------ 3. 1}$$

2.3.3.2. Edge Based Segmentation method

A connected pixel that is found on the boundary of the region is called an edge. So these pixels on an edge are known as edge points [34]. Edge can be calculated by finding the derivative of an image function. Some edges are very easy to find. These are: Ramp edge, Step edge, Roof edge, Spike edge. Step edge is an abrupt change in intensity level [34]. Ramp edge is a gradual change in intensity. Spike edge is a quick change in intensity and after that returns immediately toan original intensity. Roof edge is not instantaneous over a short distance. Edge based image segmentation method falls under structural techniques [34].

2.3.3.3. Clustering Based Segmentation

The clustering based techniques are the techniques, which segment the image into clusters having pixels with similar characteristics [34]. Data clustering is the method that divides the data elements into clusters such that elements in the same cluster are more similar to each other than others. There are two basic categories of clustering methods: Hierarchical method and Partition based method. The hierarchical methods are based on the concept of trees. In this the root of the tree represents the whole database and the internal nodes represent the clusters [34]. On the other side the partition based methods use optimization methods iteratively to minimize an objective function. In between these two methods there are various algorithms to find clusters. There are two basic types of clustering [34]: Hard Clustering and soft clustering.

Hard clustering is a simple clustering technique that divides the image into set of clusters such that one pixel can only belong to only one cluster. In other words it can be said that each pixel can belong to exactly one cluster. These methods use membership functions having values either 1 or 0 i.e. one either certain pixel can belong to particular cluster or not. An example of a hard clustering based technique is one k-means clustering based technique [34].

The soft clustering is more natural type of clustering because in real life exact division is not possible due to the presence of noise [34]. Thus soft clustering techniques are most useful for image segmentation in which division is not strict. The example of such type of technique is fuzzy c-means clustering. In this technique pixels are partitioned into clusters based on partial membership; i.e. one pixel can belong to more than one clusters and this degree of belonging is described by membership values. This technique is more flexible than other techniques [34].

2.3.4. Image Feature Extraction

Feature extraction and representation is a crucial step for multimedia processing. How to extract ideal features that can reflect the intrinsic content of the images [35]. An image feature is a distinguishing primitive characteristic or attribute of an image field [35] . Some features are natural in the sense that such features are defined by visual appearance of an image while other so-called artificial features result from specific manipulations or measurements of an image. Natural features include the brightness of region of pixels, edge outlines of objects, and grey scale textural region [35]. There are multiple ways of feature extraction basically mathematical morphology and color base feature extraction

2.3.4.1. Mathematical morphology

Mathematical Morphology (MM) is a very efficient tool for image processing, based on non-linear local operators [36] .MM is applied to extract the image's features. As a feature that understand specific information about the image i.e. location, size, orientation of certain image elements. Morphological operators are applied to find and measure objects on the image's surface.

Directional Morphological Operations means that a given operation in performed in a one, particular direction [36]In other words only neighbors from one direction are considered. The shape of neighborhood in MM is described using the notion of structuring element. Shape of the structuring element tells us how the neighborhood looks like. Two basic morphological operators are: erosion and dilation. Directional versions of them have structuring element consisting of only one neighbor of each pixel in given grid. Dilation (erosion) described in other words is a non-linear supreme filter. We consider supreme of only two points: center point and one of its neighbors, so that the image properties from one direction are considered. All possible locations of the neighbor are strictly depending on the grid type. As a consequence of that not all directions can be taken under consideration only these which describe location of neighbors in given grid.

2.3.4.2. Color based feature extraction

One of the important requirements in image retrieval, indexing, classification, clustering and etc. is extracting efficient features from images. The color feature is one of the most widely used visual features. Use of color histogram is the most common way for representing color feature [37]. Features are the image patterns which differ from its immediate neighborhood. It is usually affected by the change of an image property or several properties simultaneously, although it is not necessary localized exactly on these changes. There are mainly three properties commonly considered- intensity, color, and texture [38]

Typically, the color of an image is represented through some color model. There exist various color model to describe color information [37]. A color model is specified in terms of 3-D coordinate system and a subspace within that system where each color is represented by a single point. The more commonly used color models are RGB (red, green, blue), HSV (hue, saturation, value) and Y,Cb,Cr (luminance and chrominance). Thus the color content is characterized by 3-channels from some color model. One representation of color content of the image is by using color histogram. Statistically, it denotes the joint probability of the intensities of the three color channels. Color is perceived by humans as a combination of three color stimuli: Red, Green, and Blue, which forms a color space (Fig. 2.1). RGB colors are called primary colors and are additive. By varying their combinations, other colors can be obtained [37].. The representation of the HSV space (Fig. 2.1) is derived from the RGB space cube, with the main diagonal of the RGB model, as the vertical axis in HSV. As saturation varies from 0.0 to 1.0, the colors vary from unsaturated (gray) to saturate (no white component). Hue ranges from 0 to 360 degrees, with variation beginning with red, going through yellow, green, cyan, blue and magenta and back to red. These color spaces are intuitively corresponding to the RGB model [37].

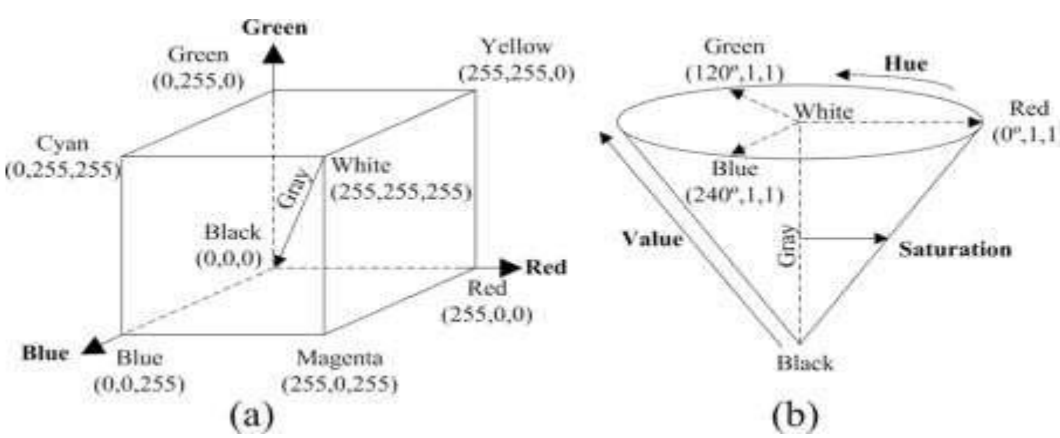

Figure 2. 1 The RGB color space (a) and the HSV color space (b)

The texture of a region can be described by roughness and softness [39]. Different regions in one image can be formed from a very rough to very soft modes. Mathematically, there are several methods for describing the texture [39]. One of these methods is the texture features based on the gray level co-occurrence matrix (GLCM) extracted from the position of the pixels with same values. This method presents an average of the entire area in which the texture is examined. Another method is to measure the spectral range of the texture based on the Furrier spectrum [39]. This spectrum describes periodic or nearly periodic two-dimensional patterns in an image. The Furrier spectrum performs spectral measurement in a polar coordinate system (i.e., based on radius and angle), since spectral properties are interpreted by describing the spectrum in polar coordinates as a simple function of S (r, Θ). In this function S is the spectral function and r and _ are variables of the polar system. Therefore, the function of S (r, Θ) can be considered as two one-dimensional functions of S Θ (r) and Sr(Θ) for each direction _ and each frequency r. S Θ (r) for the constant values of _ shows the behavior of the spectrum along the radius, while Sr(Θ) for the constant values of r shows the behavior of the spectrum along a circle with the center of origin [39].

2.3.5. Classification

For classification of image we can use different types of machine learning algorithm. Categorically machine learning divide into two parts. Those are supervised and unsupervised machine learning algorithms. Supervised machine learning is the search for algorithms that reason from externally supplied instances to produce general hypotheses, which then make predictions about future instances. In other words, the goal of supervised learning is to build a concise model of the distribution of class labels in terms of predictor features [40]. The resulting classifier is then used to assign class labels to the testing instances where the values of the predictor features are known, but the value of the class label is unknown [40].Unsupervised learning is the training of machine using information that is neither classified nor labeled and allowing the algorithm to act on that information without guidance. Here the task of machine is to group unsorted information according to similarities, patterns and differences without any prior training of data [41]. Unlike supervised learning, no teacher is provided that means no training will be given to the machine. Therefore machine is restricted to find the hidden structure in unlabeled data by our-self [41].

In this research review we look supervised machine learning. From supervised machine learning we have discus the following types of classification algorithms like naïve Bayes classifier, k-nearest neighbor and neural network, support vector machine shown below.

2.3.5.1. Naive Bayes Classifier

Naïve Bayes classifier is a classification technique based on Bayes' Theorem with an assumption of independence among predictors [40]. In simple terms, a Naive Bayes classifier assumes that the presence of a particular feature in a class is unrelated to the presence of any other feature. Even if these features depend on each other or upon the existence of the other features, all of these properties independently contribute to the probability. Naive Bayes model is easy to build and particularly useful for very large data sets. Along with simplicity, Naive Bayes is known to outperform even highly sophisticated classification methods. To build a Bayesian model is simple and particularly functional in case of enormous data sets. Along with simplicity, Naive Bayes is known to outperform sophisticated classification methods as well. Bayes theorem provides way of calculating posterior probability **P (c|x)** from P**(c)**, P**(x)** and P **(x|c)**. The expression for Posterior Probability is as follows [40].

$$\underbrace{P(c \mid x)}_{\text{Posterior Probability}} = \frac{\overbrace{P(x \mid c)}^{\text{Likelihood}}\,\overbrace{P(c)}^{\text{Class Prior Probability}}}{\underbrace{P(x)}_{\text{Predictor Prior Probability}}}$$

$$P(c \mid X) = P(x_1 \mid c) \times P(x_2 \mid c) \times \cdots \times P(x_n \mid c) \times P(c)$$

Here,

- ✓ P (c|x) is the posterior probability of class (target) given predictor (attribute).
- ✓ P(c) is the prior probability of class.
- ✓ P (x|c) is the likelihood which is the probability of predictor given class.
- ✓ P(x) is the prior probability of predictor**.**

2.3.5.2. Neural Network

A neural network consists of units (neurons), arranged in layers, which convert an input vector into some output [42]. Each unit takes an input, applies a (often nonlinear) function to it and then passes the output on to the next layer. Generally the networks are defined to be feed-forward: a unit feeds its output to all the units on the next layer, but there is no feedback to the previous layer. Weightings are applied to the signals passing from one unit to another, and it is these weightings which are tuned in the training phase to adapt a neural network to the particular problem at hand. The rightmost or output layer contains the output neurons, or, as in this case, a single output neuron. The middle layer is called a hidden layer, since the neurons in this layer are neither inputs nor outputs [42].

i. The simple neuron model

The simple neuron model is made from studies of the human brain neurons. A neuron in the brain receives its chemical input from other neurons through its dendrites. If the input exceeds a certain threshold, the neuron fires its own impulse on to the neurons it is connected to by its axon [42].

The simple perceptron model has the following behavior (see figure 2.1). First the perceptron receives several input values (x_0 - x_n). The connection for each of the inputs has a weight (w_0 - w_n) in the range 0-1. The Threshold Unit then sums the inputs, and if the sum exceeds the threshold value, a signal is sent to output. Otherwise no signal is sent. The perceptron can learn by adjusting the weights to approach the desired output [42].

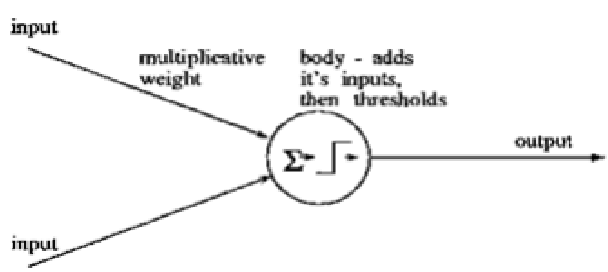

Figure 2. 2 Simple neuron model [42]

Neural Networks are successfully being used in many areas often in connection with the use of other AI techniques [42]. A classic application for NN is image recognition. A network that can classify different standard images can be used in several areas [42]:

- ✓ Quality assurance, by classifying a metal welding as whether is holds the quality standard.
- ✓ Medical diagnostics, by classifying x-ray pictures for tumor diagnosis.
- ✓ Detective tools, by classifying fingerprints to a database of suspects.

ii. Multilayer feed forward network (MLP)

The MLP model not only gives a perceptron structure for representing more than two classes, it also defines a learning rule for this kind of network. As shown in figure 2.2., the MLP is divided into three layers [42]: the input layer, the hidden layer and the output layer, where each layer in this order gives the input to the next. The extra layers gives the structure needed to recognize non-linearly separable classes [42].

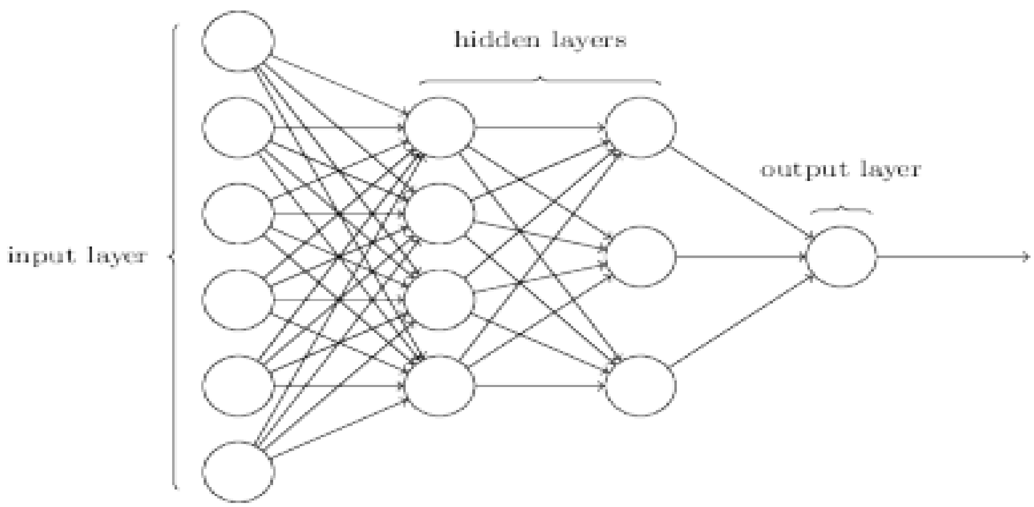

Figure 2. 3 Multilayer neural network basic architecture [43]

iii. Convolutional neural network

Convolutional Neural Network (CNN) is a Deep Learning algorithm which can take in an input image, assign importance (learnable weights and biases) to various aspects/objects in the image and be able to differentiate one from the other [43]. The pre-processing required in a CNN is much lower as compared to other classification algorithms. While in primitive methods filters are hand-engineered, with enough training, CNN have the ability to learn these filters/characteristics [43].

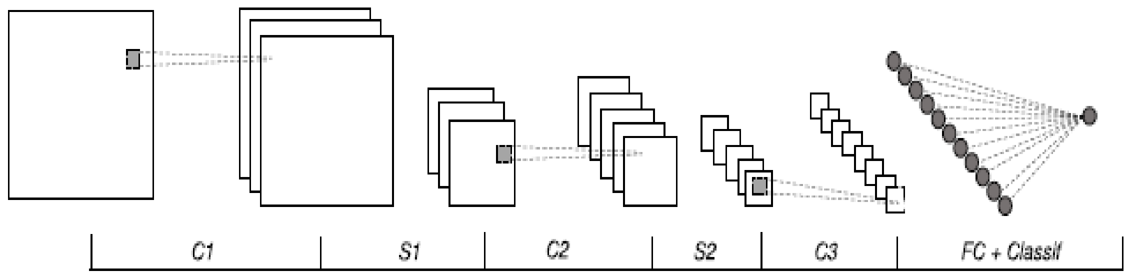

Figure 2. 4 An example of a CNN topology with 3 convolutional layers (C1, C2, and C3)

Two subsampling layers and one fully connected stage (FC). [44]

The architecture of a CNN is analogous to that of the connectivity pattern of Neurons in the Human Brain and was inspired by the organization of the Visual Cortex. Individual neurons respond to stimuli only in a restricted region of the visual field known as the Receptive Field [43]. A collection of such fields overlap to cover the entire visual area. The objective of the Convolution Operation is to extract the high-level features such as edges, from the input image. CNN need not be limited to only one Convolutional Layer. Conventionally, the first CNN is responsible for capturing the Low-Level features such as edges, color, and gradient orientation. With added layers, the architecture adapts to the High-Level features as well, giving us a network which has the wholesome understanding of images in the dataset, similar to how we would [43].

2.3.5.3. K-Nearest Neighbor

The k-nearest-neighbors algorithm is a supervised classification algorithm, and it takes a bunch of labeled points and uses them to learn how to label other points. To label a new point, it looks at the labeled points closest to that new point (those are its nearest neighbors), and has those neighbors vote, so whichever label the most of the neighbors have is the label for the new point (the "k" is the number of neighbors it checks) [43].

The case being assigned to the class is most common amongst its K nearest neighbors measured by a distance function [43]. These distance functions can be Euclidean, Manhattan, Minkowski and Hamming distance. First three functions are used for continuous function and fourth one (Hamming) for categorical variables. If K = 1, then the case is simply assigned to the class of its nearest neighbor. At times, choosing K turns out to be a challenge while performing KNN modeling. [43].

2.3.5.4. Support Vector Machine

SVM are learning systems that use a hypothesis space of linear functions in a hyperspace, trained with a learning algorithm from optimization theory that implements a learning bias derived from statistical learning theory [45]. Support vector machine is a training algorithm for classification rule from the data set which trains the classifier. It is then used to predict the class of the new sample. The aim of Classification via SVM is to find a computationally efficient way of learning good separating hyper planes in a hyperspace, where ‘good’ hyper planes mean ones optimizing the generalizing bounds and by computationally efficient mean algorithms able to deal with sample sizes of very high order [45]. SVM is expressed systematically as a weighted combination of kernel functions on training examples. The inner product of two vectors in linear or nonlinear feature space is represented by the kernel function. In a high dimensional space, SVM creates a hyper plane or set of hyper planes that define decision boundary and point to form the decision boundary between the classes called support vector threat as parameter [46].

2.3.5.5. Random forest

Random forest classifier is a meta-estimator that fits a number of decision trees on various sub-samples of datasets and uses average to improve the predictive accuracy of the model and controls over-fitting. The sub-sample size is always the same as the original input sample size but the samples are drawn with replacement.as an advantage random forest classifier **is r**eduction in over-fitting and random forest classifier is more accurate than decision trees in most cases. As drawback it have slow real time prediction, difficult to implement, and complex algorithm [47].First, start with the selection of random samples from a given dataset. Next, this algorithm will construct a decision tree for every sample. Then it will get the prediction result from every decision tree. In this step, voting will be performed for every predicted result. At last, select the most voted prediction result as the final prediction result.

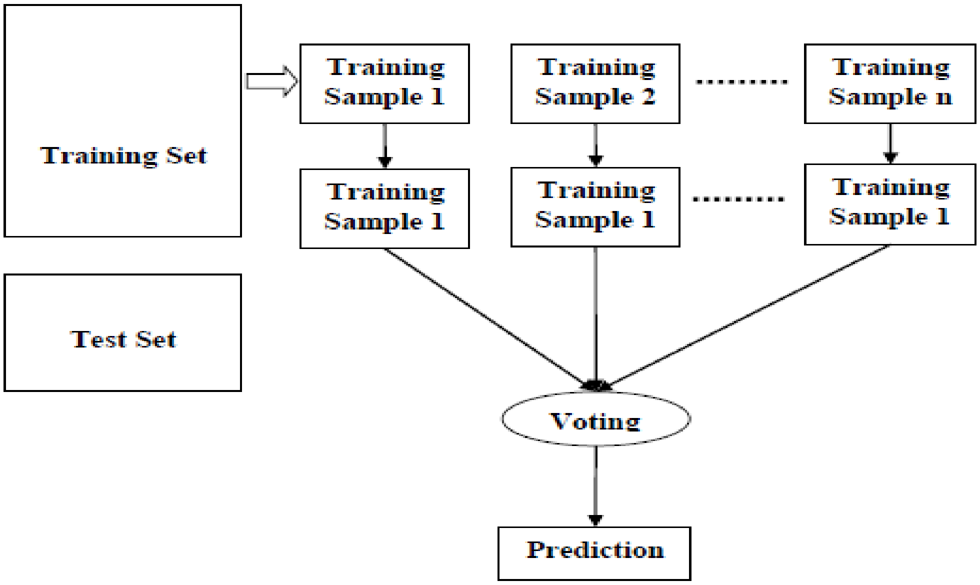

Figure 2. 5 architecture of random forest algorithm [47]

2.3.5.6. Stochastic gradient descent

Stochastic gradient descent is a simple and very efficient approach to fit linear models. It is particularly useful when the number of samples is very large. It supports different loss functions and penalties for classification. Efficiency and ease of implementation. Requires a number of hyper-parameters and it is sensitive to feature scaling [47].

2.3.5.7. Logistic regression

Logistic regression is a machine learning algorithm for classification. In this algorithm, the probabilities describing the possible outcomes of a single trial are modelled using a logistic function. Logistic regression is designed for this purpose (classification), and is most useful for understanding the influence of several independent variables on a single outcome variable. Works only when the predicted variable is binary, assumes all predictors are independent of each other and assumes data is free of missing values [47].

2.4. Application areas of image processing

The principles of digital image processing (DIP) have found applications in an amazing diversity of areas, such as astronomy, genetics, remote sensing, video communications, and biomedicine to name a few. Clearly, image processing education needs to cater to a wide spectrum of people from different educational backgrounds. Although well rooted in advanced mathematics, the theory of DIP needs to be made "accessible" to practitioners from diverse backgrounds. Complicating this is the highly multidisciplinary nature of DIP m the field draws upon a great variety of areas such as mathematics, computer graphics, computer vision, visual psychophysics, optics, and computer science. Mostly the following lists are the main application areas of image processing

2.4.1. Biometrics application

Biometry is one of the most important fields of application of image processing techniques. It has a great interest in science and technology. Security authentication and biomedical applications are fields where biometric techniques are widely used. Some of real world application is for iris recognition, face detection, finger print recognition, get security [26].

2.4.2. Military purpose

There are two compelling reasons why image processing will play an increasingly important role in future defense systems. These are the need for autonomous operation and the need to make greater use of the outputs from a diverse range of sophisticated sensors [29]. Rapid response is becoming increasingly important in Defense systems. This forces decision to be made without explicit operator intervention, in many cases operator intervention will not be physically feasible. Targeting, surveillance, command and control activities all need rapidly to make sense out of large amount of disparate and possibly unreliable information [29].

2.4.3. Health care service

In medical science, medical practitioners observe nails and palm of patient to get primary idea about diseases and health conditions of the human body. There are different application of digital image processing to simplify and support their work like x-ray, cardinal problem test, brain problem examination test, abdominal cavity examination, medical operation process with computer vision system [47].

2.4.4. Agricultural application

Image processing has been proved to be effective tool for analysis in various fields and applications. Agriculture sector have the parameters like canopy, yield, quality of product were the important measures from the farmers' point of view [48] . Most research on agricultural product are that for quality assessment and grading such as wheat [49], rice [12], species [10], coffee quality and classification [50] and more on fruits and vegetable disease identification on production and growth stage.

2.5. Related works

Quality of grains is an important requirement for today's market, to protect the consumers from substandard products. Crop yield is also the most noticeable characteristic to farmers while the crop is in the ground. But when the crop reaches to the market, quality becomes the key determinant of its sale-ability [12]. But traditional method of agricultural product quality assessment is tedious and costly [12]. According to different researchers, there are multiple mechanisms and ways of quality analysis for varieties of agricultural products in image domain.

2.5.1. Quality of Beans

According to Araújo,et al [51]., they have proposed automated beans quality inspection based on correlation-based granulometry. They built a low-cost prototype composed of a grain input box, a conveyor belt and an image acquisition chamber in the schematic design [51]. The beans are loaded in the input box, which spreads the grains in time and space. The image acquisition chamber is covered by light-tight paper to eliminate the influence of the external light .It contains a circular fluorescent lamp with translucent acrylic plate for illuminating uniformly the beans and Microsoft Life CamHD-5000 for acquiring the images [51]. They have present computers system for visual inspection of beans that classifies them according to their skin colors. After the acquisitions of image were process by MATLAB image processing tools and they have extract features for input classification of criteria's such as color and mathematical morphology results [51].

The system is composed of 3 modules: pixel color mapping, grain segmentation and grain classification [51]. In the first module, the image pixels are mapped to black (foreground), white (background) or different shades of gray depending on the color of the pixel. In the second module, each grain is segmented and spatially localized, using the correlation-based multi-shape granulometry.

In the color mapping module, they have present technique based on k-NN learning that maps a pixel to different shades of gray according to its similarity to beans color or background color [51]. In the grain segmentation module, they have used correlation-based granulometry to localize each bean grain, together with its eccentricity, size and rotation angle. This is the most important scientific contribution of this work. This technique yielded recall rate of 99.98% and precision rate of 99.99%.

Most of the food products, visual properties are the most important criteria for consumers during the selection of foods in the market [11]. Computer vision system uses for bean classification based on the skin colors of the grains proposed by [11]. They implemented computer vision system (CVS) was developed for the quality inspection of beans, based on size and color quantification of samples. The system consisted of hardware and software. The hardware was developed to capture a standard image from the samples. The software was coded in MATLAB for segmentation, morphological operation and color quantification of the sample. Image capturing system was designed to obtain standard picture from the samples [11]. The size of the system (box) was W: 35 cm, H: 45 cm and D: 35 cm. A sample loading mechanism was built in the form of a drawer. A sample holder (12 cm · 15 cm) was placed at the bottom of the box on the loading mechanism and it was covered with black material to eliminate the shadows. Four lamps were placed behind the camera and 15 cm above the sample holder [11]. A CCD was located in the center of the box and 10 cm above the sample holder. The image was digitized and collected in the computer by using Window Media Adaptor. The techniques such as binariztion, edge detection, mathematical morphology operators and color features quantification by statistical moment in MATLAB software [11]. They were performed to identify the beans based on their intensity distribution. Average, variance, skewness and kurtosis values were determined for each channel of RGB color format [11]. Artificial neural networks were used for color quantification of the beans. Samples were classified into five classes by the system and human inspectors. The overall correct classification rate of the system was 90.6%. The system had two major advantages over human inspectors. It produces high performance, reproducible and objective classification of samples, and it also eliminates the possible misclassifications of samples which might be done by human inspectors.

2.5.2. Quality of Rice

In other agricultural products, Alam, et al [52], proposes Assessment of Quality of Rice Grain using Optical and Image Processing Technique. Rice is the most favorable and most consuming food for human all over the world and researchers are working to improve the quality of rice [52]. The quality measurement of rice is also important because it is consumed as food as well as it is used for milling process in the national and international market. Researchers have already worked on the quality of grain .they proposed different techniques to characterize the quality of rice [52] . Chalky is whiteness part in the rice grain and it is one of the most important parameter that is used to evaluate the quality of rice grain. They have develop the new technology for detecting quality assessment of rice's based on different attributes to extract and judge the quality rice size ,length and chalky. Alam, et al [52] states that, they follows basic digital image processing techniques were implementing in MATLAB software .they use image acquisition by G420 scanjet scanner to digitize the sample rice to images format. Next to acquisition the researcher perform the smoothing and edge detection on digitized image to remove noise and dusts in addition to this edge detection held on the image to minimize localized error. [52] for more and deep process the researcher uses morphological analysis based on area ,length ,width and major or minor axis length .after futures extracted they uses algorithms for calculate chalky. Calculation of chalkiness is in two models RGB and HSV. They use two types of color yellow and white color rice.

The quality of the rice done by Alam et al [52] has different dependent quality result based on mean area, mean width, mean length and bases of chalky. So, from Alam et al [52] the results obtained, it is concluded that some rice are better on the basis of their length, some are better on the basis of their width while some can be termed good in quality on the basis of their area and area of the chalky.

According to Neelamegam et al [12]. In food handling industry, grading of granular food materials is necessary because samples of material are subjected to adulteration [12]. food products in the form of particles or granules were passed through sieves or other mechanical means for grading purposes [12]. Their research work analysis was performed on basmati rice granules to evaluate the performance using image processing and Neural Network is implemented based on the features extracted from rice granules for classification grades of granules [12]. Digital imaging is recognized as an efficient technique, to extract the features from rice granules in a non-contact manner. Images are acquired for rice using camera [12].

Conversion to gray scale, Median smoothing, Adaptive thresholding, Canny edge detection, Sobel edge Detection, morphological operations, extraction of quantitative information are the checks that are performed on the acquired image using image processing technique through Open source Computer Vision (Open CV) which is a library of functions that aids image Processing in real time. The morphological features acquired from the image are given to Neural Network. Their work has been done to identify the relevant quality category for a given rice sample based on its parameters.

As noted by the researcher, the performance of image processing reduced the time of operation and improved the crop recognition greatly. Grading results obtained from Neural Network system shows greater accuracy when compared with the outputs from human experts. They Uses an input image from basmati rice store and collect different variety length and color type of rice and scan by fixed point of charge coupled device (CCD) camera. Quality evaluation of Basmati rice seeds is performed via image processing. Calculations of perimeter, minor axis length, area, major axis length are done for a given sample. The rice granules are graded depending on the size of grains present in the sample. Finally, the Neural Network is not able to classify correctly and in this case the accuracy is found to be 96%.

2.5.3. Quality of Wheat

The system proposed by Xia,et al [53], is that The Analysis of Wheat Appearance Quality Based on Digital Image Processing. Wheat is a crop grown widely in China enjoying an important position in the national grain production and provision. The wheat testing technique is an effective way to guarantee quality and safety of agro-food. Moreover, the appearance of wheat such as its shape and color is related to seed quality to a certain degree [53].These features are expected to be important reference value in agricultural breeding and quality testing [53].

Xai et al [53] take wheat as research samples and has cultivated germinated wheat and musty wheat, both of which are common scenarios in wheat harvest and storage. Make the wheat well distributed on the glass surface of BENQ_5000E scanner which is used to obtain the wheat images and transfer them to the computer. They follow clear and simple image processing techniques. Images were taken in digital form and processing task held on it. According to Xai et al [53] preprocessing step the researcher perform median filtering to suffer from external disturbance like noise, after filtering segmentation were performed to determine and separate background from image content to prepare morphological oration and identify the future of wheat [53].in morphological operation there were three futures extracted those are Healthy wheat, Germinated wheat, Musty wheat, two attribute measurements like mean values and standard deviation [53]. As result from the research done by Xia et al they have test 7 morphological operation parameter and 6 color parameter and they have score 81.4 % for recognition of wheat and 89.66% for the validity and accuracy of image processing on wheat quality appearance assessments [53].

There is additional research on wheat varieties analysis proposed by Saini,et al [49]. Studies have been done on classification of wheat using machine learning algorithms and image processing. These studies have used different machine learning classifiers and have performed feature extraction for carrying out their work. Variety identification is employed to identify wheat varieties. Digital image analysis offers an objective and accuracy quantitative method for estimation of morphological feature [49]. Saini,et al [49] there are four varieties of wheat were identified by integrating machine vision and artificial neural network using MATLAB software.

2.5.4. Quality of Coffee

According to Arboleda, et al [50], they have propos An Image Processing Technique for Coffee Black Beans Identification. There are several factors that determine the quality of coffee beans including color, texture and size of coffee beans. This coffee bean quality analysis presents the control of the quality by using image processing techniques implementation [50].

Research by Arboleda et al [50] on coffee bean black detection and identification based on image processing uses to detect and identify black, small in size and color different from robust coffee family as sample to test this experiment. The study follows basic image processing steps. The snapshots of the Robusta coffee bean samples were taken by placing the samples on a white background. The camera set at 1.4x zoom was held in a position normal to the plane of the coffee beans at a distance of 12 inches directly over the plane of the sample. The coffee beans samples were well spread to deliberately avoid samples touching each other thus making bean segmentation easier and improving the accuracy of the morphology features [50]. The base of the lighting platform was placed 4 inches away from the sample platform and the LED bulb was at the height of 10 inches. In their work, 180 Robusta coffee beans were used in the process. These images were stored in JPEG (Joint Photographic Expert Group) format with size 5152 × 3864 pixels [50].The MATLAB image processing toolbox was used to develop a computer routine algorithm to preprocess and extract features of coffee samples images. Total of 180 Robusta coffee beans were used in this study. The 180 coffee beans were grouped into two major groups, the training group and the testing group. There are 70 normal beans and 50 black beans used for training and for testing 35 normal beans and 25 black beans were used for testing. The training group was used to get the RGB value range for both the normal beans and the black beans [50]. From their work the experiment start with training process .Processes are prepare range of RGB values range for normal and black coffee beans. The values extracted from training process were integrated with test process by set up maximum and minimum rage of RGB value [50]. Experiment was done by Edwin,et al [50] classification and detection technique was trained Using 70 normal beans and 50 black beans and was tested using the test sample of 35 normal beans and 25 black beans and they have get 100% classification of black and normal coffee beans accuracy was obtained in classifying and eliminating the black beans in an image using the proposed technique [50].

Quality of raw coffee beans by Redi [54] .she have Develop an automated computer vision system aiming in the establishment of technological and innovative approaches towards sample coffee bean raw quality value classification by extracting the relevant coffee bean features is the focal issue of this exploratory research [54]. In this regard is addressing the identified problems of the tedious and inefficient manual grading and sorting mechanisms of one of the most important agricultural products in Ethiopia, coffee. Prevalent sorting and classification approaches are characterized by subjective assessments of the features and nature of this huge economy representing crop, thereby influencing quality control and productivity aspects of the product. The major objective of the research spans extraction and selection of the important coffee bean morphological and color features that are useful for the purpose of classification of the raw quality grade level of sample coffee beans by designing, analyzing and testing a digital image processing model.

The automated raw quality value classification experimentation comprised the analysis of images of washed coffee beans of varying grades from Wollega region, using major attributes of morphological structures (shape and size), and color features. Grades 2 – 9 of the coffee beans were available, providing a total of 27 samples, which yielded 324 sample images after a series of re-sampling measures of same into 12 sub-samples [54].

The overall image processing work to develop models and depict trends for an efficient raw quality value classification involved sequential phases of image acquisition, image enhancement and segmentation, feature extraction, attribute selection, classification and performance evaluation [54]. The Naïve Bayes, C4.5 and Artificial neural networks (ANN) were implemented for such classification purposes. A combined morphological and color features aggregate function dataset was used to develop the base model, though model attempts with separate features were conducted. Feed-forward multilayer perceptron's with two hidden layer and backpropagation algorithms are used in the ANN classifiers [54].

Discretization of the raw quality value in to three interval classes was done to improve the performance of the model. 75% split evaluation technique was implemented for the Naïve Bayes and ANN classifiers as 10-foldcross validation evaluation techniques implemented in C4.5. Naïve Bayes classifier yielded higher model performance (82.72% correctly classified), followed by C4.5 (82.09%) and the ANN classifier (80.25%) [54].

Model robustness and sensitivity was analyzed by using perturbation analysis involving manipulations of model evaluation techniques and dataset characters. Alteration of number of beans in discretization and the use of different number of hidden layers constitute the trial modeling in this regard. Classification model was also run with various combinations of features of the coffee beans as listed with the attribute selection feature of Weka tool, where the final selection of the 21 features was done at a maximal model performance level for the Naïve Bayes and ANN classification approaches. C4.5 selected 10 features as it has its own attribute selection characteristics. An additional simulation was done with regression analysis for the sake of evaluation and trends analysis of the model outputs. A higher relation was resulted from this statistical approach between the raw quality values and the mentioned coffee bean features, supporting suitability and accuracy of dataset for classification in this research [54].

2.5.5. Quality of Sesame Grain

Research done by Hiwot [13] proposed an Automatic sesame grain classification and grading system using image processing techniques. To be competitive in the market, it is essential to assess the quality of sesame grains. Ethiopian Commodity Exchange (ECX) currently uses a manual grading system to assess the quality of the product. However, this technique is time consuming, expensive, and inaccurate and labor intensive [13]. Accordingly, it is essential to have an automated system which rectifies these problems. Thus, in this thesis, researcher present an automated system for classification and grading sesame based on the criteria set by the ECX [13]. The system takes pictures of sample sesame grains and processes the image to set the classes and grades. A segmentation technique is done to segment the foreground from the background, partitioning both sesame grains and foreign particles. The segmentation process also forms the ground work from which feature extractions are made. Color structure tensor is applied to come up with a better preprocessing, segmentation and feature extraction activities. Furthermore, watershed segmentation is applied to separate connected objects [13]. The delta E standard color difference algorithm, which generates six color features, is used for classification of sesame grain samples [13]. These six color features are used as inputs for classification and the system generates 3 outputs corresponding to types of Ethiopian sesame grains. Grading of sesame grain samples is performed using a rule based approach, where the classification output will be fed with 4 inputs and five or six outputs, corresponding to the morphological features and grades, respectively [13]. On top of that, calibration is introduced to standardize the entire system. Experiments were carried out to evaluate the performance of our proposed system design [13]. The classifier achieved an overall accuracy of 88.2%. For grading of sesame grain samples, we got an accuracy of 93.3%, far better than the manual way of grading [13].

To conclude we find the research gap on the researches quality assessments on combination of different parameters so we would like to state as parameter on image of haricot beans are color, diameters of beans from the center, mean values, length and area of the bean that cover on surface.to compute the quality of haricot bean we will use selected detection and classification machine algorithm.

Automatic maize quality Assessment system using image processing techniques done by Daniel [14],the goal of his research work is to develop a system capable of assessing the quality of maize sample constituents using digital image processing techniques and artificial neural network classifier based on the standard for maize set by the Ethiopian Standards Agency. They use a novel segmentation technique is proposed to segment and lay the foundation for feature extraction. A total of 24 features (14 color, 8 shape and 2 size) have been identified to model maize sample constituents. For classification ion of maize samples, a feedforward artificial neural network classifier with backpropagation ion learning algorithm, 24 input and 7 output nodes, corresponding to the number of features and classes respectively has been designed. The network is trained and its performance is compared against other classifiers both empirically and based on supporting facts from the literature. For the purpose of training the classifier, a total of 534 kernels and foreign matters have been collected from Ethiopian Grain Trade Enterprise. The training data is randomly apportioned into training (70%) and testing (30%). The classifier achieved an overall classification accuracy of 97.8%. The success rates for detecting foreign, rotten and diseased, healthy, broken, discolored, shriveled and pest damaged kernels are 100%, 95.2%, 98.6%, 98.8%, 100%, 98.4%, and 94.8%, respectively [14]. In this research the researcher recommend that, Due to lack of training data, this research work has not included filth. Therefore, future studies can extend this work to include filth as the eighth class to which maize sample constituents could be classified to.

Research gap

In our research like other works the Input images are haricot bean. In addition to this, others attempted to apply image processing for analyzing agricultural products such as coffee beans, sesames, wheat, barley and maize. So, features extracted such as texture, size, color, shape and also quality criteria for this product are different. In addition, reviewed researches are more concerned on rule based and mixed classification and grading system. So the researcher try to use automatic classification and grading using artificial neural network. As to the researcher knowledge there is no study conducted to apply image processing techniques for quality analysis and grade classification of haricot beans. This study fulfil better prototype for the organization like ECX and remove human error on the expertise to classify grade of haricot bean.

Chapter Three

Methods and Techniques

3.1. Overview

In this study we have proposed architectural design view for haricot bean grade classification by using digital image processing. The architecture of the model is shown in Figure 3.1 briefly.

3.2. The Proposed architecture

The architecture of the proposed work is shown in figure 3.1. Its major components include haricot bean image preprocessing, image segmentation, feature extraction, classification and grading. The architecture design starts from taking image sample of haricot bean. Next to the image taken, image preprocessing for image filtering by using median image filtering techniques and image binarization are done by using threshold values of 0.5. After image was preprocessed the result is an input for segmentation. Segmentation is done in two ways that help for feature extraction based on the number of features layers on a single image. In the classification stage the CNN extract feature of image and classify by using two types of feature layers for single image those are *Add-16* having hundred thousands of feature for single image and *fc1000* feature layers having thousands of feature layers for single haricot bean image. The model will classify the grade of haricot bean based on those feature layer. ResNet50 were the main grade classification for proposed model .Finally the model gives the output of the image class and the grade of the Bean tested as individual test input.

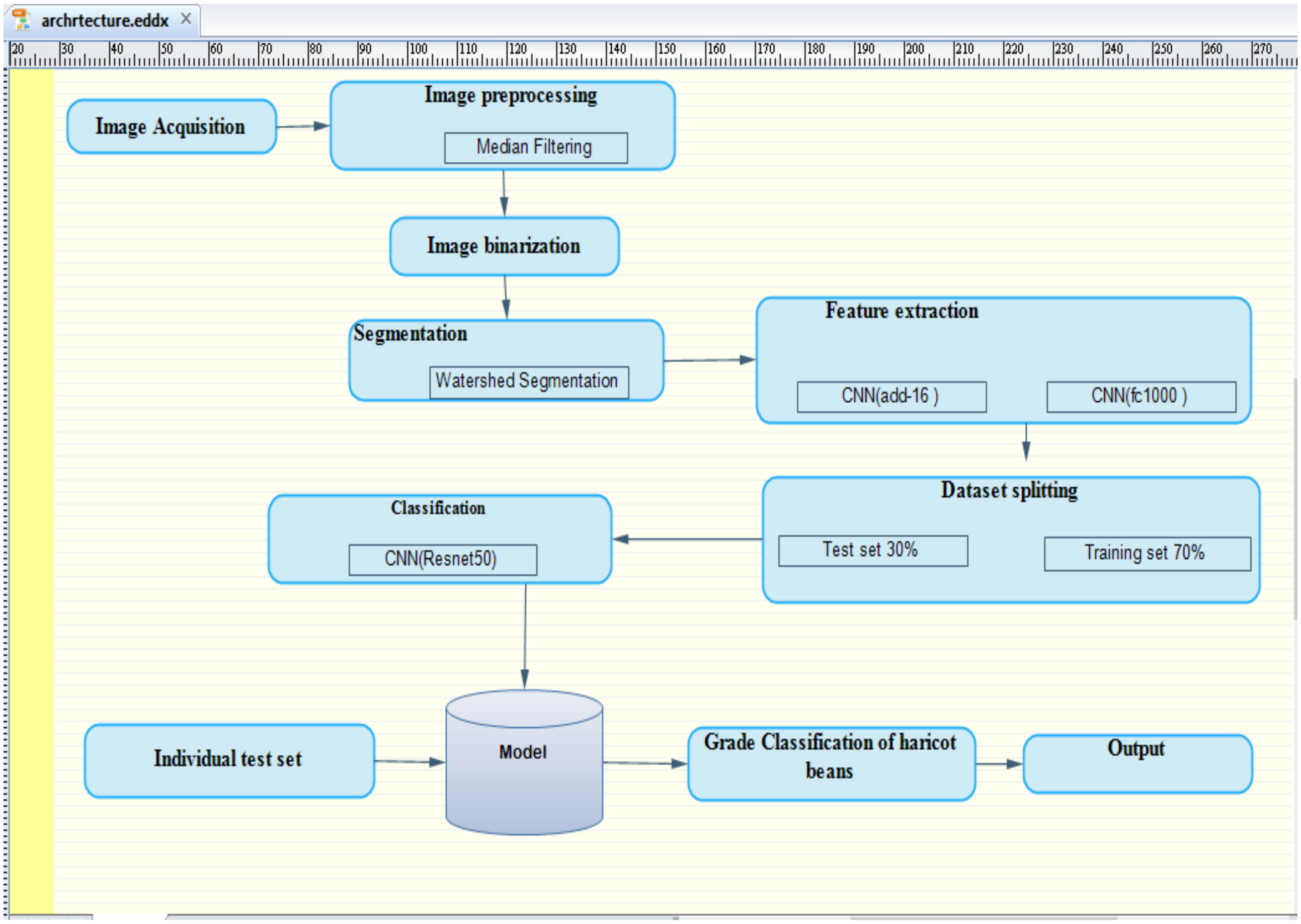

Figure3. 1 proposed architecture

3.3. Image Acquisition

Basically ECX has two types of haricot bean that are provided to the world market. Those are red and white haricot beans. White haricot image is the main input for this research. To prepare the image that is used for designing the prototype, we capture sample images from Ethiopian commodity exchange (ECX) laboratory.

For conducting experiment we use 50 images with a total of 300 images with respect to 6 classes. Haricot beans were scattered on blue background. The camera was mounted on stand to ease vertical movement and to capture stable image, the distance between the sample table and the camera was 160 mm and the lens of the camera was focused at the center of this field view vertically downward. All images were taken at resolution of 3264 x 2448 pixels. As a result, the sample image is prepared in well-defined JPEG image format. All images were taken in the same controlled environment in-order to avoid external effects of sunlight and other environmental conditions.

3.4. Preprocessing

3.4.1. Image filtering

Removal of noise is an essential and challengeable operation in image processing. Before performing any process in the image, it must be first restored. Images may be corrupted by noise during image acquisition and transmission [30]. Nature of the noise removal depends upon the type of the noise corrupting the image. In an image there will be different type of noises like impulse noise, adaptive white Gaussian noise, short noise, quantization noise, film grain, these one or more are coupled together to form a mixed noise [30]. To remove this type of noises there is a novel method comprises two stages: the first stage is to detect the noise in the image. In this stage, based on the intensity, the pixels are roughly divided into "noise-free pixel" and "noisy pixel". Then, in the second stage it is to eliminate the noise from the image. In this, only the "noise-pixels" are processed. The noise free pixels are copied directly to the output image [30].

The aim of pre-processing is an improvement of haricot beans image data that suppresses unwanted misrepresentation or enhances some image features for supplementary processing [30]. For machine viewing, Image Enhancement improves the clarity of images. Removing noise and blur, rising contrast and enlightening details from haricot images are example of enhancement operation [30] . Noise tends to molest images when picture are taken in low light setting. The proscribed lighting conditions minimize the number of irregular objects such as badly threshold haricot beans. Another issue may be spots on the inside of grains due to camera generated noise. By recognizing these qualities, minor artifacts can be easily removed by using a combination of morphological operations, then filtering remaining objects. While capturing the image, sometime it has been distorted and hence image is to be enhanced by applying special median filtering to the image to remove noise.

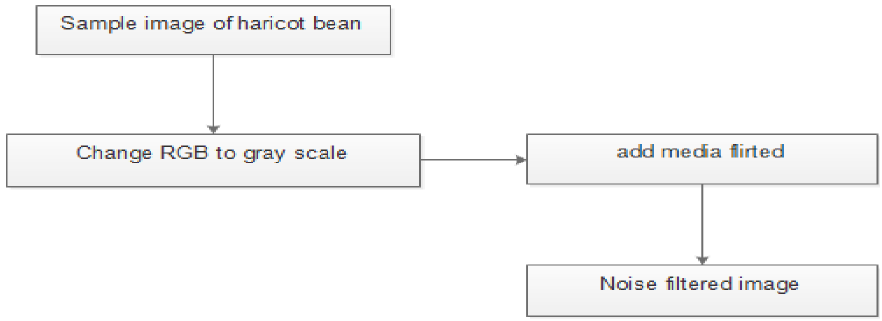

Figure 3. 2 Median filtering techniques

Median filters are useful in reducing random noise, especially when the noise amplitude probability density has large tails, and periodic patterns [30]. The median filtering process is accomplished by sliding a window over the image. The filtered image is obtained by placing the median filters of the values in the input window, at the location of the center of that window, at the output image. The median is the maximum likelihood estimator of location in the case of Laplacian noise distribution. For relatively uniform areas, the median filter estimates the gray-level value, with particular success in the presence of long-tailed noise. As an edge is crossed, one side or the other dominates the window, and the output switches sharply between the values. Thus, the edge is not blurred. The disadvantages of such filters are that in the presence of small signal-to-noise ratios they tend to break up image edges and produce false noise edges, and they cannot suppress medium-tailed noise distributions.

The median filter is normally used to reduce noise in an image, somewhat like the mean filter. However, it often does a better job than the mean filter of preserving useful detail in the image [55]. Like the mean filter, the median filter considers each pixel in the image in turn and looks at its nearby neighbor's to decide whether or not it is representative of its surroundings [55]. Instead of simply replacing the pixel value with the mean of neighboring pixel values, it replaces it with the median of those values. The median is calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value. If the neighborhood under consideration contains an even number of pixels, the average of the two middle pixel values is used [55].

3.5. Image binariztion

Image binariztion is a simple, yet effective, way of partitioning an image into a foreground and background. This image analysis technique is a type of image segmentation that isolates objects by converting grayscale images into binary images. Image binariztion is most effective in images with high levels of contrast [56].

The Binariztion technique is aimed to be used as a primary phase in various manuscript analysis, processing and retrieval tasks. So, the unique manuscript characteristics, like textual properties, graphics, line drawings and complex mixtures of the layout-semantics should be included in the requirements. On the other hand, the technique should be simple while taking all the document analysis demands into consideration. The threshold evaluation techniques are adapted to textual and non-textual area properties [56], with the special tolerance and detection to different basic defect types that are usually introduced to images. The outcome of these techniques represents a threshold value proposed for each pixel. These values are used to collect the final outcome of the Binariztion by a threshold control module. The approach is to examine the manuscript image surface in order to decide about the Binariztion method requirement. The Binariztion algorithms are to produce an optimal threshold value for each pixel [56]. Therefore we can verify about the algorithm, is best selected for obtaining the optimum thresholding value.

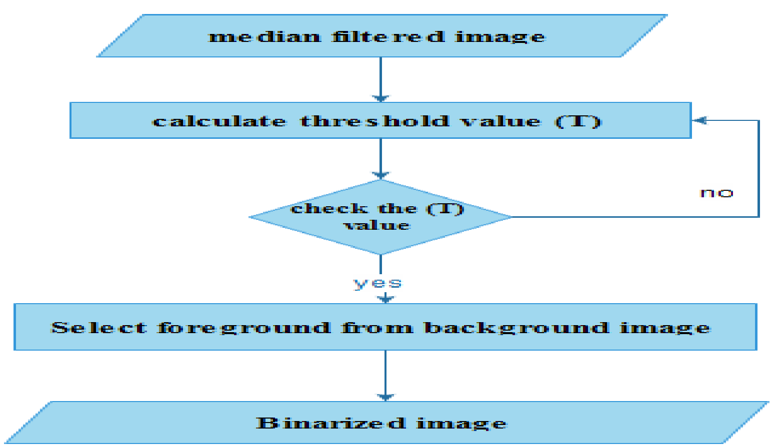

Figure3. 3 Image binariztion techniques

The algorithm for binarization of gray scale image into binary image with foreground and background separation is given as follows in algorithm 3.1.

Input: median filtered image

Output: binirized image P

- Read target image into running environment.
- Convert it to a grayscale Image if read image is an RGB Image.
- Calculate a threshold value, T
- Create a new Image Array (say 'binary') with the same number of rows and columns as original image array, containing all elements as 0 (zero).
- if gray level pixel at (i, j) is greater than or equal to the threshold value, T
  Assign 1 to binary (i, j),
- ; else
  Assign 0 to binary (i, j).

Algorithm 3. 1 *Algorithm for image binariztion*

3.6. Segmentation Algorithm

Image segmentation plays an important role in the field of image understanding, image analysis, pattern identification [33]. The foremost essential goal of the segmentation process is to partition an image into regions that are homogeneous (uniform) with respect to one or more self-characteristics and features. Clustering has long been a popular approach to untested pattern recognition. Image segmentation is important in the field of image understanding, image analysis, and pattern recognition and computer vision. The principal goal of the segmentation process is to partition an image into regions that are homogeneous with respect to one or more characteristics and features. Traditional segmentation algorithms are effective on the extraction of rigid objects. But, due to the impact of lighting in imaging process, sometimes the boundaries of object we get are not real, especially on the process of objects with varied topology structure [33].

A good segmentation is typically one in which pixels in the same category have similar grey scale of multivariate values and form a connected region, neighboring pixels which are in different categories have dissimilar values. Segmentation is often the critical step in haricot image analysis. The point at which we move from considering each pixel as a unit of observation to working with objects in the haricot image composed of many pixels. Basically we would like to segment the content of haricot beans from back ground images and particles that have less than the expected image pixel sizes so from existing background. For this purpose we have select watershed segmentation from the existing segmentation.

3.6.1. Watershed Segmentation Algorithm

Watershed is the ridge that divides areas drained by different river system. The watershed transform is a morphological gradient based segmentation technique [33]. The gradient map of the image is considered as a relief map in which different gradient values correspond to different heights. If we punch a hole in each local minimum and immerse the whole map in water, the water level will rise over the basins. When two different body of water meet, a dam is built between them. The progress continues until all the points in the map are immersed. Finally the whole image is segmented by the dams which are then called watersheds and the segmented regions are referred to as catchment basins. A catchment basin is the geographical area draining into a river or reservoir. The watershed algorithm applies these ideas to grayscale image processing in a way that can be used to solve a variety of image segmentation problem [33].

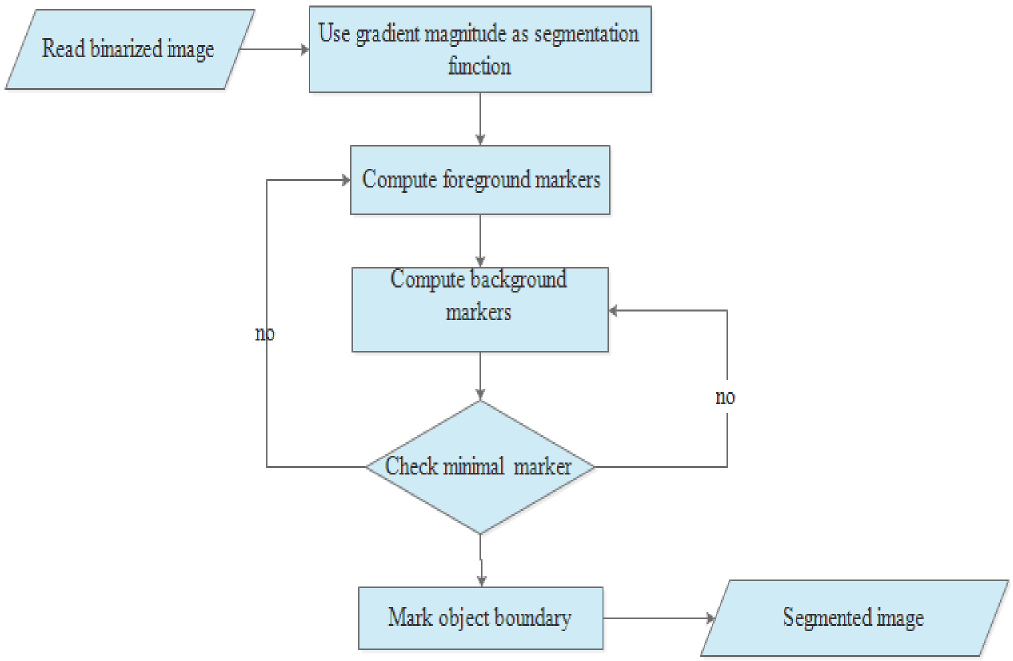

Figure3. 4 classical watershed image segmentation techniques

Hereunder algorithm 3.2 presents watershed algorithm for segmentation of haricot beans image.

Input: binirized image P

Output: segmented image q

- Convert the binirized image into components of binary
- Select the foreground markers image on image from existing back ground
- Compute background markers image using watershed
- Select foreground and create region subdivision with each object on foreground
- Combine markers and objects boundaries selected
- Create images formed with region and washed layers and lines

Algorithm 3. 2 Algorithm for image segmentation

In this research the researcher use two types of image segmentation algorithm. Those are watershed segmentation and adaptive (binirized) image for image feature extraction and image classification.

This research use mixed type of image segmentation algorithm for better classification result. The result difference is shown in scenario one scenario two and scenario three briefly.

3.7. Feature Extraction

In every image processing feature extraction is the most and well defined step to have used to classification of any image result. In this process the prototype extracts features based on color of haricot beans (white and red). The mathematical morphological analysis is calculated; as a result, the output of this two feature extraction used as classification input for grading system. The method used for feature extraction is discussed below.

3.7.1. Morphological Based Feature Extraction

Morphological features are related to the objects' shape and structure. After haricot bean image has been segmented and labeled into regions, a few basic morphological parameters are extracted as follows: minor axis (W), major axis (H), perimeter (P) and area (A). The perimeter of a region is the length of its boundary while the area of a region is defined as the number of pixels in the region. However there is a disadvantage that the application of area and perimeter is confined to situations where the size of the regions of interest should be invariant.

So we also include three more complex forms of dimensionless quantity which are insensitive to variations in size, translation and rotation. They are circularity factor (C), rectangle factor (R) and elongation factor (E), all of which are defined according to several combinations of the above mentioned basic parameters. With W, L representing respectively the major axis and minor axis and Ne, No indicating the number of chain codes, formulas for these morphological parameters is shown as follows.

i. **Area (A):** The number of pixels inside the region covered by a coffee bean, including the boundary region. It is measured by square pixels.

$$A = \sum_{(x,y)\in Q} 1 . \qquad \text{------------------------------ Eq 3. 1}$$

ii. **Perimeter (P):** The length of the outside boundary of the region covered by a haricot beans.

$$P = sqrt(2) * No + Ne$$ ----------------------------------Eq 3. 2

iii. **Elongation:** The ratio of the length of the major axis to the length of the minor axis (Elongation =Major/Minor)

$$E = Min(H, W) / max(H, W)$$ ---------------------------------Eq 3. 3

iv. **Circularity (C):** Measures the degree of roundness (circularity) of the shape the haricot beans

$$C = 4\pi A / P^2$$ ------------------------- Eq 3. 4

Algorithm 3. 3 hereunder shows the steps followed in morphological feature extraction for all haricot beans.

Input: segmented image

Output: morphological analyzed values or features

For all images in the data set

- Calculate the perimeter of the segmented foreground part of image
- Calculate the area covered by the segmented foreground image parts
- Calculate the circularity factors of the segmented parts
- Calculate the image length and width values of the segmented image that covered by foreground image
- Compute foreground markers image using elongation factors
- Combine and execute the values of foreground image values
- Extract the feature values of morphological effects

***Algorithm 3. 4** Algorithm for morphological feature extraction*

3.7.2. Color Based Feature Extraction

Image is a different kind of data which includes a huge amount of information, such as color information, objects, edges, pixel definition, dimensions and others. Therefore the treatment of image data is a sensitive concern to preserve the complete information.

RGB color space is the most common one used for images on computer because the computer display is using the combination of the primary colors (red, green, blue) to display any perceived color. Each pixel in the screen is composed of three points which is stimulated by red, green and blue electron gun separately. However, RGB space is not perceptually uniform so the color distance in RGB color space does not correspond to color dissimilarity in perception. Therefore we prefer to transform image data in RGB color space to other perceptual uniform space before feature extraction

Color is a powerful descriptor that contributes enormously to object identification. There are many color models. The RGB color model is a common one because this model can presents objects' color information, matching nicely with human visual coloration mechanism. In actual images processing, nonlinear conversion algorithm is adopted to minimize interference of brightness variation. Specifically, R, G and B component can be recalculated by the following equation [57]

r=R/(R+G+B) ------------------------- **Eq 3. 5**

g=G/(R+G+B) ------------------------- **Eq 3. 6**

b=B/(R+G+B) ---------------------------- **Eq 3. 7**

It can be found that new r, g and b component is just ratios independent of brightness variation. By virtue of being convenient for computer processing, the RGB color model plays a swift and real-time role in certain area of color extracting. However, color description of RGB is not as ideal as image color generation. By contrast, the model we are about to present, called the HIS (hue, saturation, intensity) color model is well suited for describing colors by decoupling the intensity component from the color-carrying information (hue and saturation) in a color image. Besides, converting from RGB color to HIS model is a straightforward process.

Input: for each image in the image data segmented image

Output: extracted features based on shape, size and color

- Calculate the red color values foreground part of image
- Calculate the green color values foreground part of image
- Calculate the blue color values foreground part of image
- Calculate the average intensity of RGB values for White and red haricot beans
- Combine and calculate the average RGB color values for White and red haricot beans
- Extract the feature values of morphological effects on color of haricot beans

Algorithm 3. 5 Algorithms for color based feature extraction

3.8. Classification

One of the most popular deep neural networks is the Convolutional Neural Network (CNN) [58]. It takes this name from mathematical linear operation between matrixes called convolution [58]. CNN have multiple layers; including convolutional layer, non-linearity layer, pooling layer and fully connected layer [58]. The convolutional and fully- connected layers have parameters but pooling and non-linearity layers don't have parameters. The CNN has an excellent performance in machine learning problems [58] . Especially the applications that deal with image data, such as largest image classification data set (Image Net), computer vision, and in natural language processing (NLP) and the results achieved were very amazing [58]. Important aspect of CNN, is to obtain abstract features when input propagates toward the deeper layers. In image classification, the edge might be detected in the first layers, and then the simpler shapes in the second layers, and then the higher level features.

The topology of CNN is divided into multiple learning stages composed of a combination of the convolutional layer, non-linear processing units, and subsampling layers [59] . Each layer performs multiple transformations using a bank of convolutional kernels (filters) [59]. Convolution operation extracts locally correlated features by dividing the image into small slices), making it capable of learning suitable features. Output of the convolutional kernels is assigned to non-linear processing units, which not only helps in learning abstraction but also embeds non-linearity in the feature space. This non-linearity generates different patterns of activations for different responses and thus facilitates in learning of semantic differences in images. Output of the non-linear function is usually followed by subsampling, which helps in summarizing the results and also makes the input invariant to geometrical distortions

Mainly the researcher select CNN from other classifier algorithm is that ,CNN was suitable for image input or dataset and also the classification method and the class for this research are more than two so ,the classification algorithm are better than other classifier. They execute tasks from hidden lay convolution. As much as possible the researcher think that the performance and prediction level of the classifier algorithm is better and well accurate than others.

3.9. Performance Evaluation

The confusion matrix displays the number of correct and incorrect predictions made by the model compared with the actual classifications in the test data. Confusion matrix for a classifier with two classes true and false is presented in Table 3.1

Classes predicted / Current Classes	True class	False class
True class	*True positive*	*False positive*
False class	*True negative*	*False negative*

Table 3. 1 The Confusion Matrix of a Classifier with Two Classes

The number of correctly predicted values relative to the total number of predicted values specified by Precision parameter that takes values between 0 and 1. Precision equal to 0 indicates that the model has no predictive power, it is not conclusive [60].

$$A(\text{AC})=\frac{\text{Number of correctly predicted}}{\text{number\_total\_samples}}=\frac{\text{TP Rate+FN Rate}}{\text{N+P}}$$

Recall.

- True positive Rate (TP Rate) is the fraction of positive cases predicted as positive and is equivalent to the
- False positive Rate (FP Rate) is the fraction of negative cases predicted as positive.
- True negative Rate (TN Rate) is the fraction of negative cases were correctly classified as negative.
- False negative Rate (FN Rate) is the fraction of positive cases that were incorrectly classified as negative.

From the above method of evaluation, there is two type of performance evaluation were held on this research. The first and most expecting evaluation were promising result from model. The second evaluation were the performance of the classifier algorithm for classification. On this research we show that performance evaluation by using validating test input image set and the other one is classification by random 70 % training and 30% for Turing test from total image dataset. This evaluation were done by confusion matrices mechanisms.

Chapter Four

Experiment and Result Discussion

4.1. Overview

The quality of the haricot bean was performed based on different characteristics and quality criteria's. Mainly the quality was based on size, shape and color with texture of the bean. Quality Classification of haricot bean based on image processing was perform by using white type of class without the additional out layers, that means the classification algorithm depends on the size and shape. In addition to this, the classifier extracts different features from segmented images.

The researcher takes 300 images and each image is subdivided based on their class. The classes are grade one, grade two, grade three, grade four, grade five and lower grade (lg). According to Ethiopian commodity exchange laboratory expertise lg grade are not categorized as class but they must use to identify the basic class.

4.2. Dataset Preparation

The main data set preparation held on all grades of haricot bean. In Ethiopian commodity exchange there are 6 grades that have been assigned by organization experts .The data set was prepared by their grades level and each grade level have 50 images, totally the dataset have 300 images that are captured in the same environments. The beans are classified by ECX expertise. The main criteria for this classification are color, size and shape. The experts consider the foreign maters in variations of grade of the haricot bean but the first thing they are visualizing is that, those three layers (color, size and shape) are inspected. Accordingly, the research prepared 3 dataset for the classification and grading experiment. The first dataset was segmented image input, which used to extract size and shape. The second is the binirized image with threshold value 0.5, and the third one is segmented image which are not binirized input and extract features of color, shape and size.

Summary of the data set used for training and test are presented in table 4.1 below

Grade	**training set**	**Individual(validating) test set**
G1	50	15
G2	50	15
G3	50	15
G3	50	15
G4	50	15
G5	50	15
Lg	50	15
Total image	300	90
Total	**390**	

Table4. 1 Size of the dataset

On table 4.1 shows that, there is 390 images each image subdivided six classes. The model take only 300 images for training the model. Then, the training image were split by model for training and Turing test by using random data splitting methods in to 70 % (210)images for training and 30%(90)image of the data were for Turing test . Finally the remaining 90 image were used for validate and test individually on each class and also the promising result of each scenarios were taken from those validation test result.

Figure 4.1 below presents multiple haricot beans image captured using the selected camera.

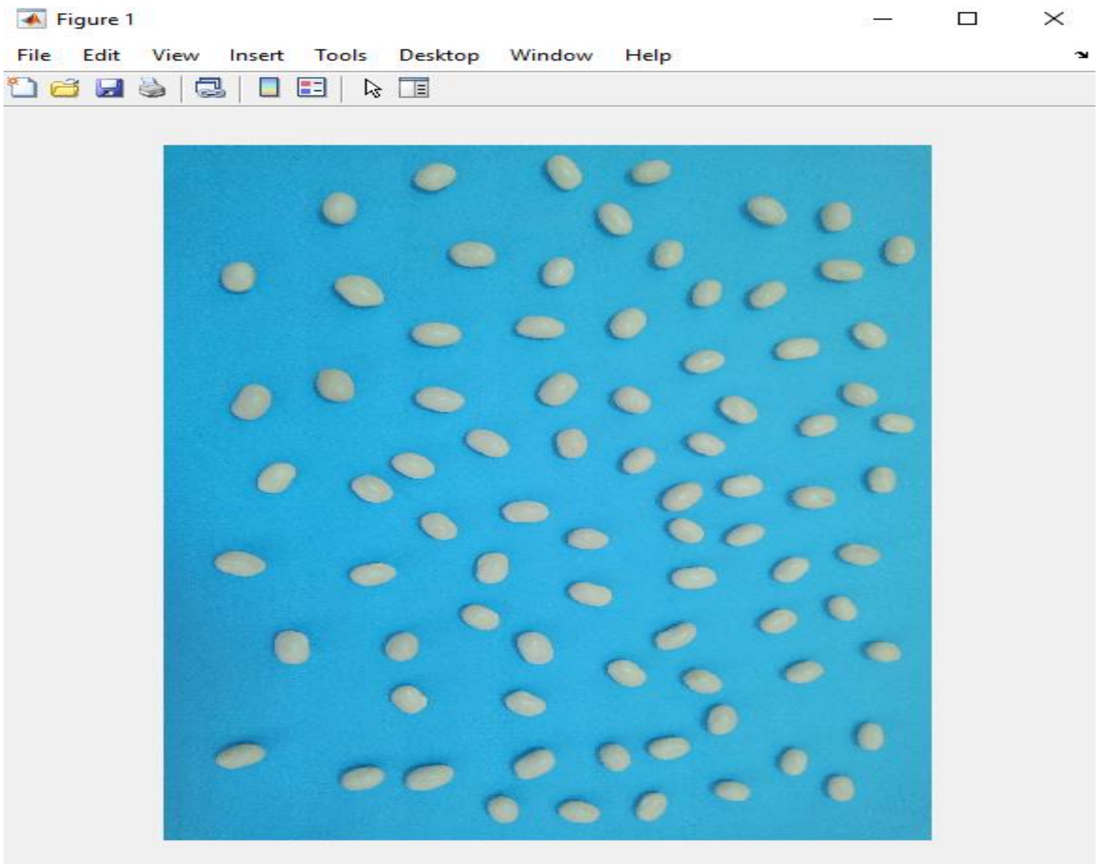

Figure 4. 1 Sample haricot bean

4.3. Noise Removal from Haricot Bean

The process of removing noise and unwanted spot is critical before using images. According to different scholars [55], use of filtering techniques such as averaging and Gaussian filters causes image smoothing. For this study we use Median filtering for noise reduction and smoothing because it protect the edges of the image during noise removal and is mostly used in digital imaging and effective with salt and paper noise .The noise in the input gray color haricot beans image is detached using median filter. Median filter considers each pixel in the haricot beans image in turn and looks at its nearby neighbors to decide whether or not it is representative of its surroundings. Instead of simply replacing the pixel value with the *mean* of neighboring pixel values, it replaces it with the *median* of those values. The median is calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value.

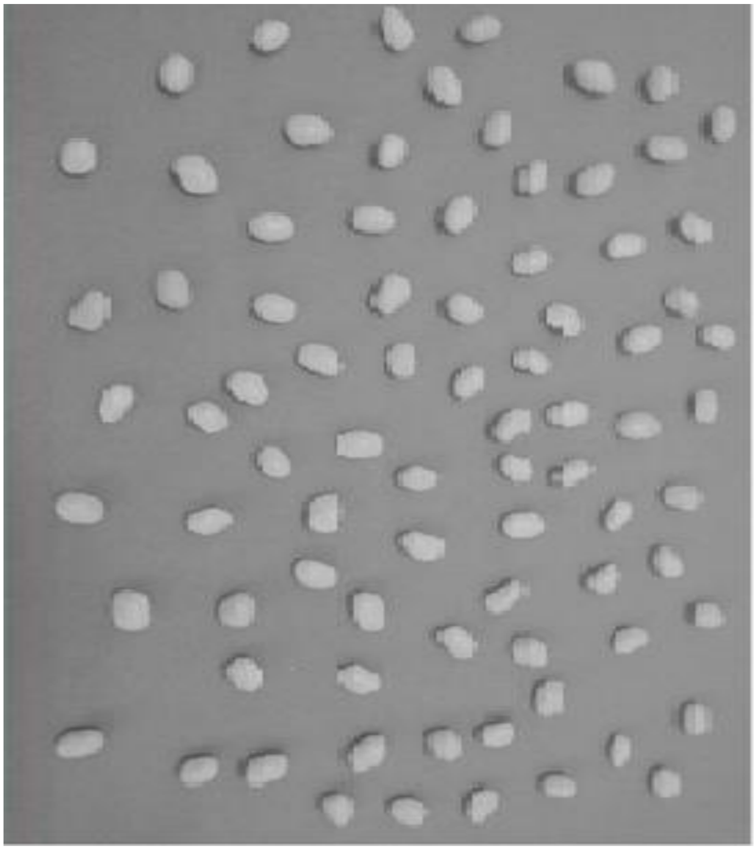

Figure 4. 2 Median filtered haricot bean image

4.4. Haricot Bean Image Binariztion

Binarization converts the grayscale image I to binary image BW, by replacing all pixels in the input image with luminance greater than level with the value1 (white) and replacing all other pixels with the value 0 (black). This range is relative to the signal levels possible for the image's class. Therefore, a level value of 0.5 corresponds to an intensity value halfway between the minimum and maximum value of the class.

Using binarization the researcher converts a grayscale image to binary image. As shown in figure 4.3, binarization produces an image with black and white color only. Binariztion method is easy to understand and simple to implement. The resultant binary image is easy to analyze. The reason to use this process is to help the classifier to extract shape and size features better and also to increase the accuracy of the classifier.

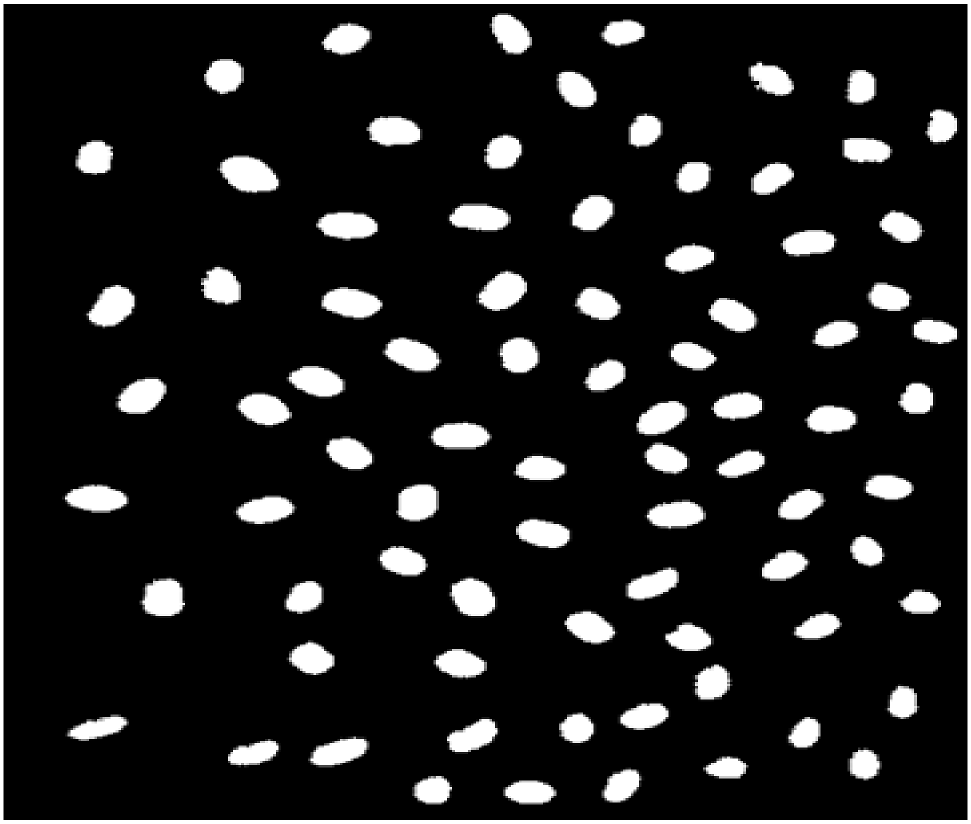

Figure 4. 3 Binirized haricot bean image

4.5. Haricot Bean Image Segmentation

Image segmentation is the process of partitioning an image into sub regions that are similar. This division into parts is often based on the characteristics of the pixels in the image. One way to find regions in an image is to look for abrupt discontinuities in pixel values, which typically indicate edges. These edges can define regions. Other methods divide the image into regions based on color values or texture. Image segmentation is the division of haricot image into regions or categories, which correspond to different objects or parts of objects. Every pixel in haricot image is allocated to one of a number of these categories.

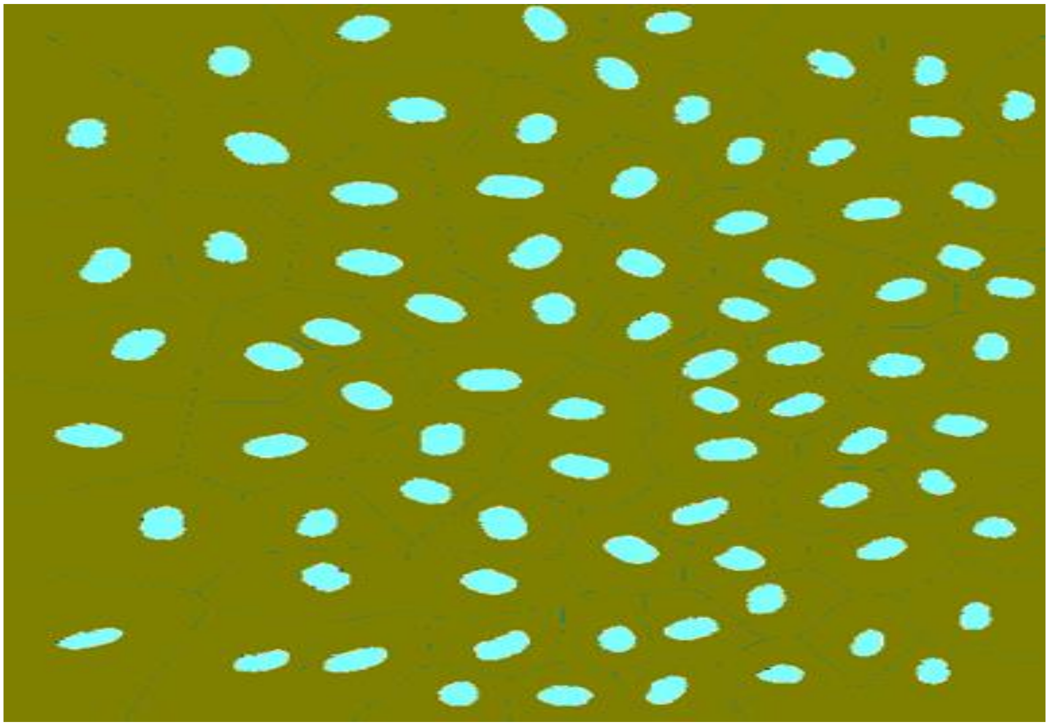

Figure 4. 4 Segmented haricot bean image

As show in figure 4.4 the researcher segment the binirized image by using watershed segmentation algorithm. This algorithm help the feature extractor to extract feature from sub divide each haricot bean image parts. So, the researcher use this algorithm to crate boundary of each haricot beans.

4.6. Haricot bean feature extraction and classification

Convolutional Neural Networks (CNN) are a special type of Neural Networks, which have shown state-of-the-art performance on various competitive benchmarks. The powerful learning ability of deep CNN is largely due to the use of multiple feature extraction stages (hidden layers) that can automatically learn representations from the data. Classification performs by artificial neural network classification model especially convolutional neural network. It is suitable for classification of image processing based input data type. Some layer within a CNN are suitable for image feature extraction the layers at the beginning of the network capture basic image feature, such as edges and blobs [61] .The classification algorithms add hundred thousands of features extracted from single image. This feature extraction helps to haricot bean classification in shape, size and area coverage on the foreground parts. The researcher use *ResNet-50* deep learning convolutional network (CNN) classification algorithms with *fc1000* and a*dd_16* feature layer extraction. The pre-trained *ResNet-50* network use *fc1000* feature layers as shown on figure 4.5 shows that extracted and figure 4.6 shows a*dd-16*. Those pre-trained feature extractor were use six class of the dataset categories

traningFeatures
1000x210 single

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	-0.2536	0.0075	-0.1894	-0.2822	-0.3755	-0.3321	-0.5892	-0.5990	-0.5540	-0.5461	-0.6028	-0.5018	0.1205
2	1.2702	1.1960	1.1457	1.0869	1.0937	1.0901	1.2975	1.3139	1.2898	1.4256	1.4197	1.2652	1.3418
3	0.9359	1.1127	1.1862	0.8256	0.7969	0.8277	0.6326	0.6143	0.6439	0.4790	0.5146	0.3480	1.3768
4	0.4410	0.6563	0.6656	0.1987	0.1345	0.1668	-0.1591	-0.1922	-0.1347	0.0313	0.0382	-0.4226	0.6257
5	3.2263	3.3300	3.2037	3.0435	2.9986	3.0726	2.7587	2.7371	2.7741	2.4224	2.4289	2.5544	3.3994
6	7.3956	7.7300	6.9777	6.8232	6.6530	6.7751	6.3814	6.3874	6.5342	5.9384	5.8858	6.7890	7.6812
7	7.3262	7.7071	7.0779	7.2300	7.0257	7.1727	6.6924	6.6909	6.8518	6.3876	6.3305	6.9522	7.6539
8	0.4597	0.5100	0.4213	0.5059	0.4792	0.5040	0.5851	0.5912	0.5809	0.6457	0.6835	0.6309	0.3517
9	-1.8444	-1.6403	-1.7975	-1.8032	-1.8268	-1.7845	-1.9833	-1.9559	-1.9171	-1.9321	-1.9597	-1.7193	-1.7838
10	-0.4478	-0.4070	-0.5843	-0.9268	-0.8989	-0.8659	-0.7371	-0.7369	-0.7292	-0.3170	-0.2863	-0.8027	-0.1378
11	-3.5953	-3.6219	-3.6375	-3.6874	-3.6482	-3.6929	-3.6788	-3.6877	-3.7117	-3.4645	-3.4437	-3.5396	-3.2007

Figure 4. 5 sample screenshot for fc1000 feature extraction

On figure 4.5 the feature extractor from training data with a single image 1000 features. This shows that, from 70% of the training data the sample screenshot show 1000 feature layers with 210 images.

traningFeatures
100352x210 single

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	-1.1545	-1.1919	-1.2181	-1.2152	-1.2325	-1.2178	-0.8225	-0.8626	-0.8529	-0.8401	-0.1140	-1.0356	-0.875
2	2.1385	2.1212	2.0761	2.1309	2.0194	2.0599	1.8797	1.9326	1.9597	1.9985	3.7174	4.6103	4.434
3	4.2269	3.2086	3.3251	3.3238	3.2852	3.0231	2.7764	2.7573	2.7720	2.7412	2.0778	3.3806	3.015
4	4.3778	3.0078	2.9963	2.9323	3.1013	2.6436	4.5800	4.6204	4.3535	4.3122	4.7480	4.0991	4.064
5	6.3333	4.9190	5.0611	4.7739	5.0611	4.5819	6.0344	6.0416	6.2312	6.3995	8.4164	6.0789	6.035
6	0.4918	1.6925	1.8211	1.5289	1.8440	1.6628	1.9448	1.8971	1.7958	1.8070	1.7541	3.2836	2.831
7	-0.8653	-0.4492	-0.4222	-0.4528	-0.4026	-0.4630	-0.7180	-0.7448	-0.8649	-0.8330	-0.8519	-0.7402	-0.913
8	-0.7435	-0.6550	-0.6350	-0.6154	-0.6907	-0.5658	4.1325	4.1959	3.9087	4.0719	4.6694	2.3331	1.234
9	3.3594	3.2502	3.1978	3.2822	3.2069	3.2333	4.9670	5.0999	4.9800	5.2014	5.1262	4.7317	5.186
10	6.3249	3.8693	4.1169	3.7621	3.9813	3.8964	3.7304	3.6376	3.8657	3.5974	4.0076	2.5595	2.578
11	5.6174	3.7843	3.8347	3.7346	3.8148	3.8557	4.0081	3.9281	4.0077	3.7967	4.2985	2.3961	2.471

Figure 4. 6 Sample screenshot for add-16 feature extraction

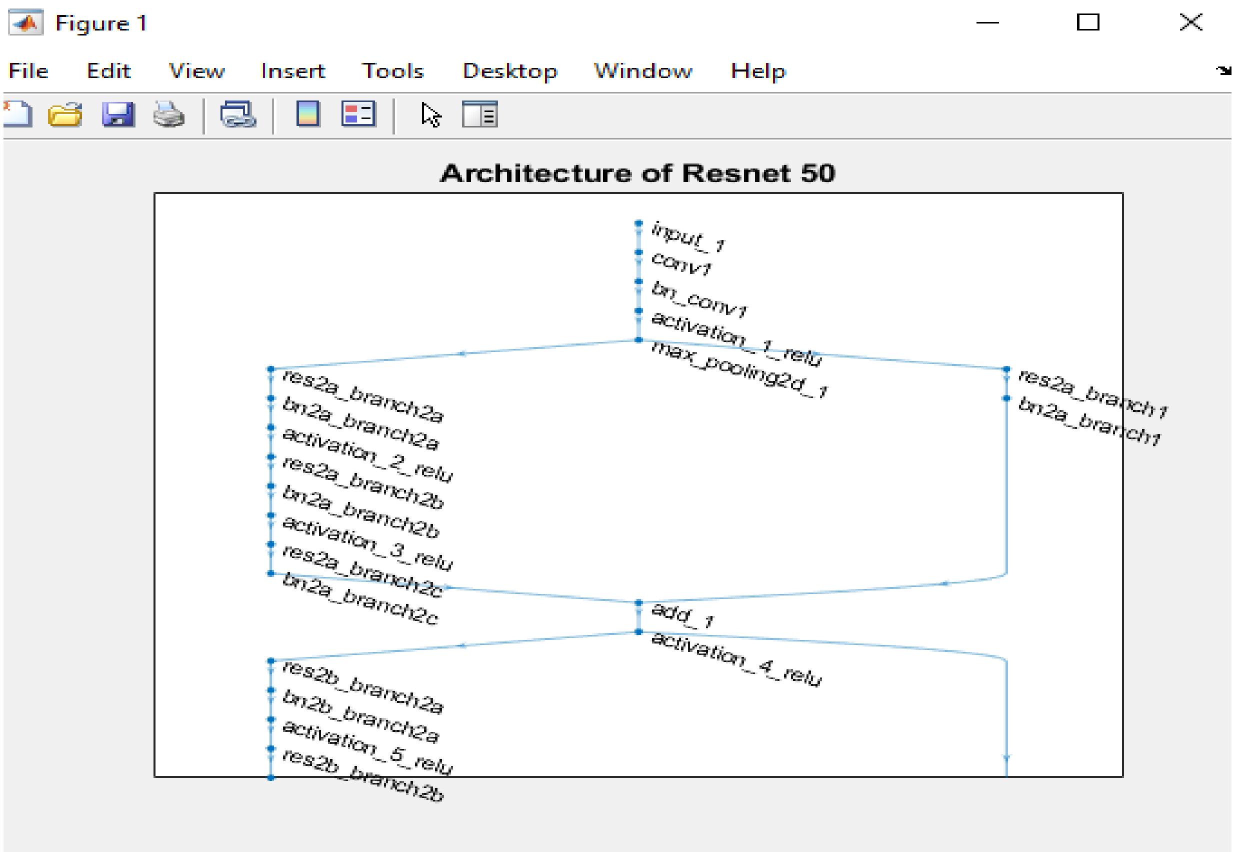

Figure 4. 7 Architecture of ResNet-50

ResNet-50 is a convolutional neural network that is trained on more than a million images from the ImageNet database. The network is 50 layers deep and can classify images into 1000 object categories. The network has learned rich feature representations for a wide range of images. The network has an image input size of 224-by-224. For more pertained networks in MATLAB. ResNet-18 is a convolutional neural network that is trained on more than a million images from the ImageNet database. The network is 18 layers deep and can classify images. The network has learned rich feature representations for a wide range of images. The network has an image input size of 224-by-224 it us as classification input [18].DenseNet-201 is a convolutional neural network that is trained on more than a million images from the ImageNet database [18]. The network is 201 layers deep and can classify images. As a result, the network has learned rich feature representations for a wide range of images. The network has an image input size of 224-by-224 it us as classification input [18].

On the above CNN classifier package ResNet18 have use lower connectivity layers within classification image set. This classification connectivity layers are smaller and not effective like ResNet50 and DesNet201 classifiers. desnet 201 were tested on this research but the result on the performance and promising result have the same response and result were got. Then, the researcher compare the execution time to select best algorithm. So, the time taken to classify single haricot bean grade by desnet 201 takes average time 120 seconds and relatively ResNet 50 take average time of 80 seconds for execution. In this research we would like to take

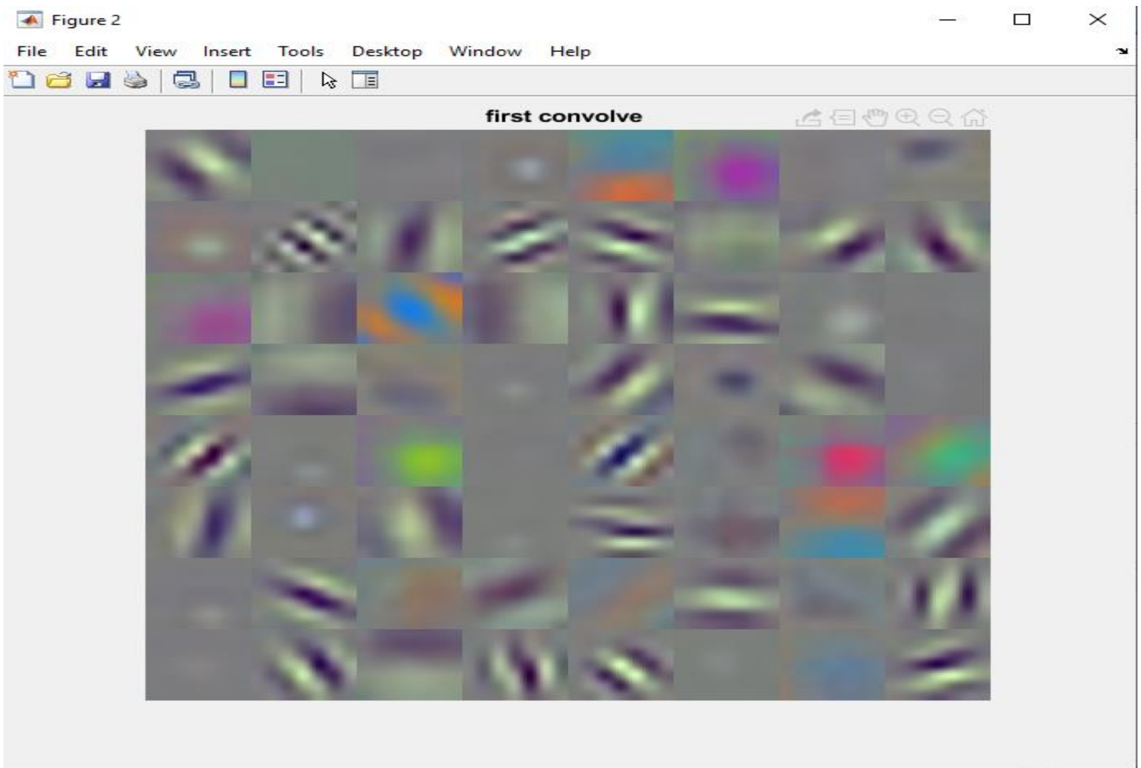

Figure 4. 8 First convolved layer

In different agricultural products there are different types of quality assessment mechanism; most of the time fruits are evaluated based on the skin color and the expected shape or size [62]. The number of feature extracted from single image of the haricot bean are the main criteria CNN used for haricot beans quality evaluation.

4.7. Experimentation

In this experimental test, the researcher prepared 300 haricot beans image data set for training, Tuning and testing. 15 images are prepare for individual test to evaluate the performance of the classification model .from each individual test single image have 6.67% of representation. So, the result will be displayed on those scenarios discussed below.

The experiment is conducted in three consecutive scenarios. Each scenario differs based on their training set.

- In scenario one the input for classifier algorithm is binirized and watershed base segmented image and individual test set.
- For the second scenario the input image is prepared based on adaptive threshold segmentation.
- For the third scenario the input images were median flirted and segmented with watershed segmentation algorithms

In each of the scenarios the researcher uses *add-16* and *fc1000* for image feature layers. This feature extractor perform and extract the number of feature with single image. *add-16* feature layers provide one hundred thousands of feature from single image unit. The other type of classifier ware tested in this research is *fc1000*, this feature layers have the capacity of use one thousand features for single image. After all the extracted feature use for image classification. Haricot bean grade classification model uses CNN classification algorithm for grading system.

In this research, each scenario have trained mode and its own average accuracy. That means on the training data done by MATLAB. So, the researcher prepare measurement and performance evaluation of the algorithm with confusion matrices. In each scenario the classifier algorithm have validating test input given by model tester (researcher) and also have promising result accordingly with algorithm performance throughout the experimentation.

4.7.1. Scenario One

The first scenario takes totally 300 image of haricot bean with each class having 50 images. The image noise was removed by using median image filtering techniques. After all the filtered gray scale image were binirized with threshold values of 0.5. The binirized image segmented using watershed image segmentation algorithm and the algorithm segments each bean on the image by region. We prepared the segmented image on dataset. From the segmented image the feature extractor algorithm extracts image feature based on numbers of feature layers provided by CNN feature extractor and image classifier algorithms.

The classifier algorithm subdivided the original dataset into training set and test set using percentage split of 70 % (210 images) for training and 30 % 90 images for classifier test set. For individual test, we used additional 90 images; out of which for model evaluation purpose 15 images considered for each class. Summary of the result is presented in table 4.2 below.

Predict class	Grade one	Grade two	Grade three	Grade four	Grade five	Grade LG
Grade one	**93.33%**	6.67%				
Grade two	6.67%	**86.66%**	6.67%			
Grade Three			**93.33 %**	6.67%		
Grade four			6.67%	**86.66%**	6.67%	
Grade five				6.67%	**86.66%**	6.67%
Grade LG					6.67%	**93.33%**
Classification Model Achieved						**90.0%**

Table 4.2 Performance result of scenario one

From the above table 4.2 we have summarized classification performance of haricot bean by using binirized image with watershed segmented image. According to this procedure, the model achieves 93.33%, 86.66%, 93.33%, 86.66%, 86.66%,93.33% for grade one, grade two, grade three, grade four, grade five and lower grade, respectively. In general the classification model achieved 90.0% average individual test accuracy and 99.2% Average classifier accuracy. There is misclassification on input test image. The reason to misclassification for grade one product to grade two were the capturing environment which is the gap between the capturing cameras is greater than from fixed point. The classifier grade as the product on grade two. For all grade the classification lead whether previous class or next class. This problem is happen by the environmental setup of the capturing media. The capturing media set on the top of the product on 160 mm and for individual test the camera set to 155mm and 165mm. This setup lead the classifier to misclassification of haricot bean grade.

4.7.2. Scenario Two

The other classification of haricot bean grade experiment is done by applying noise removal on binarized image, but no segmentation of the image involved. From this binarized image the image feature extraction is done by CNN and the researcher uses both *add-16* and *fc1000* classifier for binarized image dataset. Experimental result is presented in table 4.3 below.

Predict class	Grade one	Grade two	Grade three	Grade four	Grade five	Grade LG
Grade one	**86.66%**	6.67%				6.67%
Grade two	6.67%	**86.66%**	6.67%			
Grade Three	6.67%		**86.66%**	6.67%		
Grade four		6.67%	6.67%	**80.0%**		6.67%
Grade five				6.67%	**86.66%**	6.67%
Grade LG				6.67%	6.67%	**80.0%**
Classification Model Achieved						**84.44%**

Table4. 3 Summary of experimental result of scenario two

From the above experimental result presented in table 4.3, we have summarized classification performance of haricot bean by using binirized image with noise removal without applying watershed segmentation algorithm, where the classifier extract features from the whole haricot bean image. According to this procedure, the model achieves 86.66%, for grade one, grade two, grade three and grade five. On the other hand, for grade four and grade LG (lower grade) the accuracy is 80%. In general the classification model achieved 84.44% Average individual test accuracy and 95.3% average classifier accuracy. There are misclassification of grade, this result caused by the capturing environmental setup and the performance of classifier algorithm. Another reason for misclassification ware the segmentation technic which is used in this scenario cannot be capable for segment the overlapped beans.

4.7.3. Scenario Three

This scenario was done by taking original image of haricot beans and appliers median filtering techniques to reduce noises on images that are exposed to different image noises. To identify haricot beans from the filtered images, watershed segmentation algorithm is applied. Finally, at the end of segmentation we prepare 300 segmented images as training set and individual test set for classifiers. The CNN classifier takes 70% of the original data set as training set and 30% of the data set to self-test set. Finally the researcher tests the accuracy of the classifiers by using independent test having 15 images in each class with a total of 90 images for the 6 classes. Summary of the test result is presented in table 4.4 below.

Predict class	Grade one	Grade two	Grade three	Grade four	Grade five	Grade LG
Grade one	**86.67%**	6.67%			6.67%	
Grade two	6.67%	**86.66%**	6.67%			
Grade Three	6.67%		**86.66%**	6.67%		
Grade four		6.67%	6.67%	**80.00%**		6.67%
Grade five				6.67%	**86.66%**	6.67%
Grade LG				6.67%	6.67%	**86.66%**
Classification Model Achieved						**85.55%**

Table4. 4 Summary of experimental result of scenario three

In the above experimental result presented in table 4.4, a summary of classification performance of CNN classifier for haricot bean grayscale image is given by extracting features from a segmented filtered image. According to this scenario, the model achieves 86.67%, accuracy for all grades except grade four which achieves an accuracy of 80%. In general the classification model achieved 84.44% average individual test accuracy and 96.8% average classifier accuracy. The classification algorithm depends on the data set prepared by researcher. This shows that the performance of classifier (CNN) algorithm always greater than the accuracy of the individual test result. In this scenario, misclassification were happen when the mixed type of grade were captured like grade one with grade two and respect grade.

4.8. Discussion of Result

In this discussion the researcher indicate that, grade classification of haricot bean was done by convolutional neural network (CNN). The classifiers algorithm takes different feature layers. We have test layers of feature extraction based on number of layer; the first number of layers are *fc1000* x 1 single image and second layer were *add_16* feature layers that have 100352x1 single image layers used to extract features. As the number of feature increase the accuracy and the exact response and grading system performance increased with big accuracy difference. To show the direct proportion of feature increase the exact result of the test are also increase. So, we show that on below table 4.5.

Out of the three scenarios we experimented, CNN classifier tested on filtered, binarized and segmented grayscale image achieves the best accuracy of 90.0%. As a result we selected this classification model for designing a prototype of classification and grading of haricot beans Images.

In this research the researcher find and show the experimental result and also shows the expected result between *add-16* and *fc1000* in The table below table 4.5 show that the summary of result shown in the experiment .

Scenarios	Segmentation methods	Number of input image	Convolutional neural network classifier (ResNet50)	
			add-16	***fc1000***
Scenario one	Binarize and watershed segmented (mixed)	300	**90.0%**	83.35%
Scenario two	Only binarized (adaptive)	300	84.44%	80.01%
Scenario three	Watershed segmentation	300	85.55%	81.13%

Table 4. 5 Short result summary

On the table 4.11 shows that the performance difference in classifier algorithm. The researcher use *add-16* and *fc1000* CNN image classifier. So, this table show that the number of feature layers increases the performance of the classifier also increase. The difference are shown on scenario one result.

There is summary that shows on table 4.6 the result Comparison with other researchers

Author and year	Work on product	Classifier used	Promising result
Asma Redi 2011	Raw Coffee bean quality	Naïve Bayes, c4.5 and ANN	82.75,82.09% and 82.25% respectively
Hiwot Desta 2015	Sesame grain grading	Delta E and Rule base	88.2 %
Araujo et al 2015	Bean quality inspection	Correlation granulometry	99.98 %
Proposed model	Haricot bean grade classification	Convolutional neural network	**90.56%**

Table4. 6 Result comparison between different researchers

4.9. Performance Evaluation

Performance evaluation of the classifier was an important way of checking the usability of system algorithm. It used for identifies in which class and label the input data make an error and in which class have exact result as given input. In classification problems, good accuracy in classification is the primary concern; however, the identification of the attributes or features having the largest separation power is also of interest. Even more, for very large data sets the classification is highly dependent on feature selection. This is mainly because the larger the number of attributes, the more sparse the data become and thus many more training data are necessary to accurately sample such a large domain [60].

Classes predicted / Current Classes	**Grade One**	**Grade Two**	**Grade Three**	**Grade Four**	**Grade Five**	**Grade Lg**	**Total**
Grade one	**0.933**	**0.067**	0	0	0	0	1
Grade two	**0.067**	**0.87**	0.067	0	0	0	1
Grade Three	0	0	**0.933**	**0.067**	0	0	1
Grade four	0	0	**0.067**	**0.87**	**0.067**	0	1
Grade five	0	0	0	**0.067**	**0.87**	**0.067**	1
Grade LG	0	0	0	0	**0.067**	**0.933**	1
Average classification						***0.90***	

Table4. 7Confusion Matrix for performance of CNN

In table 4.7 shows that, the accuracy of system for quality classification of haricot bean image classification. The classification have the accuracy of 0.90 X 100 %. Finally we have look that, if the number of image increased the performance will be better. The performance indicate that the system is usable and can be solve human error in advanced way. The selected experiment result have error rate of 10 %.

Chapter Five
Conclusion and Recommendation

5.1. Conclusion

Haricot bean is a commercial commodity that plays a major role in earning foreign currency among export commodities of Ethiopia. Countries including Ethiopia produce haricot bean for both domestic and export consumptions. Even if the experts are highly skilled, they may get tired and exposed to bias. As far as the researcher's knowledge is concerned no effort has been made by research to support the grading process of Ethiopian haricot bean. In this study, an attempt has been made to construct a model for the classification and grading of Ethiopian haricot bean. The research follows experimental research methodology and techniques. On this phase of experimental test the researcher use images of haricot bean.

Once the image of haricot beans was captured median filtering techniques is used to reduce the effect of noise in the image. After the noise was removed the researcher try to apply binarization to convert to binary image, which makes easy image segmentation into sub-regions by watershed segmentation algorithm. Once the segmentation process completed, feature extraction is done to represent the image. This process is done via convolutional neural network (CNN). Which is a well-defined and good image classifier.to classify grade of haricot beans are by using *add-16* and *fc1000* as compression on classification.

Experimental result shows that the model constructed in this study registers a promising result of 90.0 % accuracy. From the result we have conclude that the dataset which is noise filtered, binarized and segmented using watershed segmentation algorithm has good performance.

There are challenges faced by the researcher. The main challenge for this research was sample collection from Ethiopian commodity exchange laboratory. The production season of haricot bean was start from December up to February. This was causes to limit the researcher to collect varieties of samples. On the other hand, the preparation of dataset and image capturing was more tedious and time taking tasks. Selecting and image capturing environment and lighting arrangement are the other issue.

The accuracy the classification algorithm depends on of the segmentation and feature extraction and also, the number of the image on the dataset. The segmentation algorithm which used by researcher were binarized and watershed segmented image set (scenario one), adaptive threshold or binarized image set (scenario two), and watershed segmented image set (scenario three) with 25 input image in each class that have 150 image totally. CNN feature extractor and *fc1000* classification were used. Then the result shown as 77.08%, 70.83%, 72.91% of promising result respectively. By using the above input dataset with CNN feature extractor and *add-16* classifiers, the researcher got 83.33%, 77.08 % and 81.25% respectively. When the number of image were increased with double, there are grate performance difference on the classification. We have prepare 300 images in each three sub categories: watershed segmented and segmented (binarized) image set (mixed), adaptive threshold (binirized), and then segmented) image set and watershed segmented image set. By using CNN feature extractor and *add-16* classifiers, the researcher have got 90.0%, 84.44%, 85.55%, Promising result in each respective scenarios. Other experiment were used by CNN feature extractor and *fc1000* classifiers and we have got 83.35%, 80.01%,81.13% Finally we have select best promising result we have got from binirized and then segmented image set were better performance the average performance of the classifier(CNN) were 99.2 %.

5.3. Future Work

This research attempt the grade classification of haricot beans by using digital image processing. From the experimental result and based on the findings of this study, the following recommendations are forwarded for further research works.

- ✓ The need for improve the accuracy of the classification by increasing dataset size of the haricot bean with different out layers like dirty and mixed components.
- ✓ By changing classification and feature extraction algorithm ,we recommend researchers to perform and design prototype for collection of product which detect the grade classification haricot bean ,coffee bean, maze ,seamen grain which is exchanged in Ethiopian market

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ANNEX

Annex one: Segmentation code for binirized image

```
%%%%%%%%%Segmentation code for binirized image %%%%%%%%%%%%%%
imagepath =('D:\my file\orginal Dataset\traning\bw')
d=dir([imagepath '\*.jpg'])
for i=1:length(d)
 I=imread([imagepath '/' d(i).name]);
%  I = rgb2gray(rgb);
% imshow(I)
gmag = imgradient(I);
imshow(gmag,[])
% title('Gradient Magnitude')
L = watershed(gmag);
Lrgb = label2rgb(L);
imshow(Lrgb)
% title('Watershed Transform of Gradient Magnitude')
se = strel('disk',13);
Io = imopen(I,se);
imshow(Io)
% title('Opening')
Ie = imerode(I,se);
Iobr = imreconstruct(Ie,I);
imshow(Iobr)
% title('Opening-by-Reconstruction')
Ioc = imclose(Io,se);
imshow(Ioc)
% title('Opening-Closing')
Iobrd = imdilate(Iobr,se);
Iobrcbr = imreconstruct(imcomplement(Iobrd),imcomplement(Iobr));
Iobrcbr = imcomplement(Iobrcbr);
imshow(Iobrcbr)
```

```
% title('Opening-Closing by Reconstruction')
fgm = imregionalmax(Iobrcbr);
imshow(fgm)
% title('Regional Maxima of Opening-Closing by Reconstruction')
I2 = labeloverlay(I,fgm);
imshow(I2)
% title('Regional Maxima Superimposed on Original Image')
se2 = strel(ones(5,5));
fgm2 = imclose(fgm,se2);
fgm3 = imerode(fgm2,se2);
fgm4 = bwareaopen(fgm3,13);
I3 = labeloverlay(I,fgm4);
imshow(I3)
% title('Modified Regional Maxima Superimposed on Original Image')
bw = imbinarize(Iobrcbr);
imshow(bw)
title('Thresholded Opening-Closing by Reconstruction')
D = bwdist(bw);
DL = watershed(D);
bgm = DL == 0;
imshow(bgm)
% title('Watershed Ridge Lines)')
gmag2 = imimposemin(gmag, bgm | fgm4);
L = watershed(gmag2);
labels = imdilate(L==1,ones(3,3)) + 2*bgm + 3*fgm4;
I4 = labeloverlay(I,labels);
imwrite(I4,[d(i).name]);
end
```

Annex Two: Classification using CNN (Add-16) feature

```
###############for classification of haricot bean #################################

file=fullfile('D:\my file\orginal Dataset\segmentedbinay')
catagorie={'g1','g2','g3','g4','g5','lg'}
imds = imageDatastore(fullfile(file,catagorie),'LabelSource', 'foldernames',...
   'FileExtensions', {'.jpg', '.png', '.tif'})
tbl=countEachLabel(imds);
minSetcount=min(tbl{:,2});
imds=splitEachLabel(imds,minSetcount,'randomized');
countEachLabel(imds);
g1=find(imds.Labels=='g1',1);
g2=find(imds.Labels=='g2',2);
g3=find(imds.Labels=='g3',3);
g4=find(imds.Labels=='g4',4);
g5=find(imds.Labels=='g5',5);
lg=find(imds.Labels=='lg',4);
% % figure
% % subplot(2,2,1);
% % title('grade 2');
% % imshow(readimage(imds,gradeone));
% % subplot(2,2,2);
% % title('grade 2');
% % imshow(readimage(imds,gradetwo));
% % subplot(2,2,3);
% % title('grade 3');
% % imshow(readimage(imds,gradethree));
% % subplot(2,2,4);
% % title('grade 4');
% % imshow(readimage(imds,grlg));
net=resnet50;
% net=densenet201;
```

```
% % inputSize = net.Layers(1).InputSize;
% % net = googlenet;
% % figure
% % plot(net)
% % title('archtecture on res net 50');
set(gca,'YLim',[150,170]);
net.Layers(1);
net.Layers(end);
numel(net.Layers(end).ClassNames)
[trainigSet,testSet]=splitEachLabel(imds,0.3,'randomize')
ImageSize=net.Layers(1).InputSize
augmentedTrainingSet=augmentedImageDatastore(ImageSize,trainigSet,'colorpreprocessing','gr
ay2rgb');
augmentedTestSet=augmentedImageDatastore(ImageSize,testSet,'colorpreprocessing','gray2rgb')
;
w1=net.Layers(2).Weights
w1=mat2gray(w1)
% figure
% montage(w1)
% title('first convolve ');
% featureLayer='fc1000';
featureLayer='add_16';
traningFeatures=activations(net,augmentedTrainingSet,featureLayer,...
   'MiniBatchSize',32,'OutputAs','columns')
traningLabels=trainigSet.Labels
classifier=fitcecoc(traningFeatures,traningLabels,'learn',...
'linear','coding','onevsall','ObservationsIn','columns')
testFeatures=activations(net,augmentedTestSet,featureLayer,...
   'MiniBatchSize',32,'OutputAs','columns')
predLabel=predict(classifier,testFeatures,'ObservationsIn','columns')
testLabels=testSet.Labels
confmat=confusionmat(testLabels,predLabel)
```

```
confMat=bsxfun(@rdivide,confmat,sum(confmat,2))
accurency=mean(diag(confMat));
newImage=imread('D:\my file\orginal Dataset\testset\test2\bw\segbinirazed\test2 (4).jpg')
ds=augmentedImageDatastore(ImageSize,newImage,'colorpreprocessing','gray2rgb');
imageFeatures=activations(net,ds,featureLayer,...
    'MiniBatchSize',32,'OutputAs','columns')
Label=predict(classifier,imageFeatures,'ObservationsIn','columns')
as1=sprintf('it belonges %s gread ' , Label)
```

Annex Three: Image filtering

```
###################median filtering ##################################

imagepath =('D:\my file\orginal Dataset\traning ')
d=dir([imagepath '\*.jpg']);
for i=1:length(d)
 I=imread([imagepath '/' d(i).name]);
 I1 = rgb2gray(I);
J = imnoise(I1,'salt & pepper',0.02);
Kmedian = medfilt2(J);
imwrite(Kmedian,[d(i).name]);
end
```

Annex four Classification using CNN (fc1000) features

```
################for classification of haricot bean ##################################

file=fullfile('D:\my file\orginal Dataset\segmentedbinay')
catagorie={'g1','g2','g3','g4','g5','lg'}
imds = imageDatastore(fullfile(file,catagorie),'LabelSource', 'foldernames',...
    'FileExtensions', {'.jpg', '.png', '.tif'})
tbl=countEachLabel(imds);
minSetcount=min(tbl{:,2});
imds=splitEachLabel(imds,minSetcount,'randomized');
countEachLabel(imds);
```

```
g1=find(imds.Labels=='g1',1);
g2=find(imds.Labels=='g2',2);
g3=find(imds.Labels=='g3',3);
g4=find(imds.Labels=='g4',4);
g5=find(imds.Labels=='g5',5);
lg=find(imds.Labels=='lg',4);
% % figure
% % subplot(2,2,1);
% % title('grade 2');
% % imshow(readimage(imds,gradeone));
% % subplot(2,2,2);
% % title('grade 2');
% % imshow(readimage(imds,gradetwo));
% % subplot(2,2,3);
% % title('grade 3');
% % imshow(readimage(imds,gradethree));
% % subplot(2,2,4);
% % title('grade 4');
% % imshow(readimage(imds,grlg));
net=resnet50;
% net=densenet201;
% % inputSize = net.Layers(1).InputSize;
% % net = googlenet;
% % figure
% % plot(net)
% % title('archtecture on res net 50');
set(gca,'YLim',[150,170]);
net.Layers(1);
net.Layers(end);
numel(net.Layers(end).ClassNames)
[trainigSet,testSet]=splitEachLabel(imds,0.3,'randomize')
ImageSize=net.Layers(1).InputSize
```

```
augmentedTrainingSet=augmentedImageDatastore(ImageSize,trainigSet,'colorpreprocessing','gr
ay2rgb');
augmentedTestSet=augmentedImageDatastore(ImageSize,testSet,'colorpreprocessing','gray2rgb')
;
w1=net.Layers(2).Weights
w1=mat2gray(w1)
% figure
% montage(w1)
% title('first convolve ');
% featureLayer='fc1000';
featureLayer='add_16';
traningFeatures=activations(net,augmentedTrainingSet,featureLayer,...
   'MiniBatchSize',32,'OutputAs','columns')
traningLabels=trainigSet.Labels
classifier=fitcecoc(traningFeatures,traningLabels,'learn',...
'linear','coding','onevsall','ObservationsIn','columns')
testFeatures=activations(net,augmentedTestSet,featureLayer,...
   'MiniBatchSize',32,'OutputAs','columns')
predLabel=predict(classifier,testFeatures,'ObservationsIn','columns')
testLabels=testSet.Labels
confmat=confusionmat(testLabels,predLabel)
confMat=bsxfun(@rdivide,confmat,sum(confmat,2))
accurency=mean(diag(confMat));
newImage=imread('D:\my file\orginal Dataset\testset\test2\bw\segbinirazed\test2 (4).jpg')
ds=augmentedImageDatastore(ImageSize,newImage,'colorpreprocessing','gray2rgb');
imageFeatures=activations(net,ds,featureLayer,...
   'MiniBatchSize',32,'OutputAs','columns')
Label=predict(classifier,imageFeatures,'ObservationsIn','columns')
as1=sprintf('it belonges %s gread ' , Label)

###################median filtering #################################
```

```
imagepath =('D:\my file\orginal Dataset\traning ')
d=dir([imagepath '\*.jpg']);
for i=1:length(d)
 I=imread([imagepath '/' d(i).name]);
 I1 = rgb2gray(I);
J = imnoise(I1,'salt & pepper',0.05);
Kmedian = medfilt2(J);
imwrite(Kmedian,[d(i).name]);
end
```