MEASURING THE SEVERITY OF FUNGI CAUSED DISEASE ON LEAF USING TRIANGULAR THRESHOLDING METHOD

By

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STUDENT'S DECLARATION

I hereby declare that the whole of this work is the result of my individual effort and that all quotations from books and other sources of information have been duly acknowledged and that no part of it has been presented for another award of a degree in this University or elsewhere.

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DEDICATION

This research work is dedicated to the Glory of the Lord. It is also dedicated to my wife and children, my mother and my siblings Juliana Amoah, Ntiwaa Naomi, Stephen and Christian Antepim and Florence Tawia. You have been my stronghold.

ABSTRACT

In recent years, agriculture has become much more important than it used to be some years back where plants were only used to feed humans and animals. This is due to the fact that plants are now used to generate electricity and other forms of energy to improve living conditions of humans. For this reason, there is the need to take proper care of plants in order to get the maximum benefits from them. One major area that needs urgent attention is curbing plant diseases. There are several diseases that affect plants that can cause great harm to various economies and societies. It can even lead to great ecological losses. For this reason, it is better to diagnose plant diseases accurately and timely to avoid such loses. Fungi caused diseases in plants are the most common diseases which appear as spots on plant leaves. These spots make it very difficult for such plants to prepare their food by means of Photosynthesis since they affect the green pigments (chlorophyll) in the leaf, hence to a large extent affects the growth and the yield of such plants. In case of severe infection, the leaf becomes totally covered with spots and this leads to the withering of the plant. Plant disease can be detected and severity estimated using Thresholding and Segmentation. This paper employs the Triangular thresholding method with a written algorithm to detect and measure the severity of fungi caused disease on leaves. It can also be used to detect diseases caused by bacterial on plant leaves. The algorithm is estimated to give up to about 97% accurate results.

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CHAPTER ONE

INTRODUCTION

Background of the study

In recent years, agriculture has become much more important than it used to be some years back where plants were only used to feed humans as well as animals. This is due to the fact that plants are now used to generate electricity and other sources of energy to improve upon the living conditions of mankind. However, there are so many diseases that affect plants that can cause great harm to various economies and societies. It can even lead to great ecological losses. For this reason, it is better to diagnose diseases accurately and timely to avoid such loses. Plant diseases can be detected through several means including manual and computer based systems. Most plant diseases appear as spots on the leaves which are more visible to human eye. On the other hand, there are some diseases that do not appear on the leaves and others appear in the later stages when they have already caused great harm to the plants. In such instances, it is recommended that computerized systems would be the only option to detect the situation timely using some kind of complex algorithms and analytical tools, preferably through the use of powerful microscopes and other machines. In some other instances, the signs can only be detected through the electromagnetic means which produces more images that are not visible to the human eye. Another means of achieving this is through technique known as Remote Sensing Technique (RST) that examines and diagnoses using multi and hyper spectral image captures. All the methods that use the RST approach usually fall on digital image processing tools to achieve their desired results. Most of the diseases that affect plants are caused by fungi which appear as spots on plant leaves. These spots make it very difficult for such plants to prepare their food by means of photosynthesis since they affect the green pigments in the leaf, hence to a large extent affects the growth and the yield of such plants. In circumstances where the fungi infection becomes severe, the spots cover the entire surface area of the leaf. The diseases in plants do not only reduce the yield but can also deteriorate the variety of such plants and its withdrawal from cultivation. Plant diseases especially leaf diseases are usually curbed using insecticides, fungicides and pesticides. However, excessive application of these chemicals for the treatment of plant diseases can result in poisoning their produce as well as causing other harms to humans and animals. The danger of toxic residue on crops due to the application of pesticides on plants that have been affected by various forms of diseases has been identified as a major contributor to ground water pollution and contamination. Again, too much application of pesticides by farmers increase cost of production which can lead to greater loss. Therefore, there is the need to minimize their use due to the above reasons. One major way of achieving this is by estimating the severity of the affected area of the plant severity focusing on the diseased area, with the appropriate quantity and concentration of pesticides. The use of naked eye observation and manual methods are generally used to decide disease severity in the production practice but that may result in several errors and inaccurate results. Other methods such as Grid counting can be used to improve the accurate level however, this approach is difficult to use and also consumes a lot of time. The application of image processing techniques in conducting research in the agric sector has helped in diverse ways to improve upon the development of the agricultural sector. There are so many approaches used by some researchers to detect, measure and classify leaf diseases on plants. Some of these methods include the Bounding Box, Moment Analysis, Colour Analysis, Support Vector Machine and Neural Networks. However, none of these methods have adopted by the various researchers has been outstanding. This paper seeks to detect measure and quantify the severity of fungi caused disease on leaves using the Triangular Thresholding method. What makes this method unique is the fact that it is simple, easy to use and provides accurate results.

1.1 Statement of problem

Fungi-caused diseases on plant leaves are the most common diseases which appear as spots on plant leaves. This if not treated at the right time may lead to severe loss. Here in Ghana and other parts of the world, farmers incur huge losses due to diseases that attack their farm produce. Plant diseases such as African Cassava Mosaic Disease (ACMD) and Anthracnose Disease that affect cassava plants affect farmers in their harvest. Others like Anthracnose lesions and Alternaria lesions on watermelon foliage, as well as Papaya apical necrosis on pawpaw leaf do affect crop production in Ghana. Apart from the loss to farmers, extreme use of fungicides and pesticides for plants diseases increase the cost of production and can also pollute our physical environment; therefore, there is the need to minimize their use. To achieve this, the diseased areas must be targeted by applying the rightful quantity and concentration of fungicides and pesticides by estimating the severity of the disease using image processing methods.

1.2 Research Objectives

Generally, the study seeks to measure the extent to which fungi caused diseases affect plants most especially, plant leaves. Specifically the study seeks to:

1. Detect and identify fungi caused diseases on plant leaf.
2. Quantify and measure the severity of the fungi caused disease on plant leaves.
3. Suggest the appropriate quantity and concentration of fungicides to use on plant leaves based on the disease severity.

1.3 Research Question

1. How best can image processing method be used to detect fungi caused disease on plant leaf?
2. What methods could be used to measure and quantify the severity of fungi caused disease on leaves?
3. What amount of fungicides could be used on plant leaves?

1.4 Scope of the Study

The study concentrated mainly on detecting and measuring the severity of fungi caused diseases on leaves. It also looked into the image processing techniques and methods. These included history about image processing, methods and techniques as well as the merits and demerits of image processing. It further looked into the some diseases that affect plant leaves through fungi and the possibilities of measuring the diseases on leaves through image processing techniques specifically; the simple and triangular thresholding methods.

1.5 Limitations of the Study

In the course of the research, the researcher realized that certain aspects of the study were beyond his control. Hence, little or nothing was done about such situations. Some of such limitations include the following:

The research work was restricted to only three plants namely, watermelon, cassava and sugarcane. Due to limited time and financial resources, the researcher could not gather all the necessary information needed to cover most plants that have their leaves been affected by fungi.

Also, it was a bit difficult getting accurate and up-to-date information from experts who had knowledge on some of the issues that could have been discussed in the research.

1.6 Significance of the research

It is an undisputable fact that the technology has come to stay and there is no way we can avoid its use. It is therefore left to the users to use it judiciously to improve their living conditions. In the first place, this study would enable Agric Extension Officers to appreciate the importance of image processing in their field of work. It will also help achieve high yield due to the fact that plant diseases can be detected and cured using appropriate concentration of fungicides.

Also, the study would help reduce excessive toxic waste to water bodies as well as plants that turn to affect human life. The study will also help reduce cost of production that brings huge losses to farmers due to excessive use of fungicides on their plants.

Again, the outcome of the study can provide important suggestions and feedback to the appropriate authorities in order to put in place proper measures as far as agricultural production is concerned especially, in situations where there is outbreak of plant diseases.

Finally, this study would serve as a reference material for other researchers who would want to conduct further research into the problems related to image processing and plant diseases.

1.7 Organization of the study

The work is organized into five different chapters. The first chapter provides the primary introduction of this study. It proposes the extensive construction inherent in this study. It thus provides adequate background of information to allow the reader understand the reason behind the study and what the researcher intends to accomplish by undertaking the study. The chapter gives an overview of the whole study. Chapter two of the work reviews earlier research related to the research topic with specific reference to the research objectives. It presents extracts from books, journals and collected works that are helpful in carrying out this work and justifying key conclusions and recommendations. Chapter three provides details of how data was collected, organized and analyzed. It suggests the varied techniques and tools used to collect and analyze data to gain valid results. Chapter four provide research findings and analysis obtained through the methodology outlined in chapter three. The final chapter, chapter five provides a summary of findings and conclusions from the study and recommendations for users of the research.

CHAPTER TWO

REVIEW OF RELATED LITTERATURE

2.0 Introduction

The purpose of this study is to measure the severity of fungi caused diseases on leaves using the triangle and simple threshold methods.

This chapter covers the examination of existing literature in relation to the study. Materials written by other persons or authors in context with the topic were considered.

The chapter deals with sub-topics including the definition, origin and uses of image processing, image processing methods in relation to disease severity and effects of fungi caused diseases on plants.

2.1 Image Processing

Rao (2014), is defined as the process of improving and enhancing the raw images that are taken through digital cameras, sensors, and many other sophisticated means such as Satellite, space probes and aircrafts for various applications. When someone suggested thousands of years ago that

"a picture speaks a thousand words", probably the idea of computing was limited to basic number crunching. Above adage still has significance to computing with images. Most researchers in computer vision and image processing aim at deriving effective and better tools as well as proper approaches that give different ideas on the same image by providing means to comprehend not only the content of the image but also give meaning, and significance of the image. There is no way image processing can be compared or matched with the human eye in terms of accuracy, but it can outperform it easily on observational consistency, and ability to carry out detailed mathematical operations. Again, image processing can be used to compute and find solutions to simple or structured tasks by providing reliable, consistent and cheap results. Unlike some years back, researches conducted based on image processing in recent years have been broadened widen to cover a large range of information ranging from simple and basic pixel based low-level operations to high-level analysis that now includes the use sophisticated tools including techniques like artificial intelligence for the purposes of interpretation and understanding of the image. These new and modern techniques for processing images are being developed to get a better meaning and understanding of images based on the relationship between its components, its context, and its history if it is a part of a sequence, and a priori knowledge gained from a range of images.

2.1 Uses of Image Processing

(Jayamala K. Patil and Rai Kumar, 2011) identified about five main uses of image processing in respect to agricultural plants and their fruits. In their research, they identified that image processing is very useful to:

1. Detect plant leaves, stems and fruits that are affected by diseases.
2. Quantify the areas affected by disease in plant leaves, fruit and stems.
3. Detect the shape of the area of the leaves, fruits and stem that has been affected.
4. Determine the colour of the affected areas and finally
5. Find out the size and shape of fruits.

(K.M.M. Rao, 2014)also identified some uses of Image Processing as applied and used in various applications such as Material Science, Agriculture,Remote Sensing, Medicine,Document processing, engineering, Non-destructive Evaluation, Forensic Studies, Textiles, Military,Printing Industry, Film industry and Graphic design.

2.3 Image Processing Methods

Rao (2014) presented two main methods of image processing. In his paper, he presented Analog image processing as the first method. This method refers to the changes, modification and adjustment of image through electrical means. A typical example of this method is the image produced by the television. The television transmits signals in a form of voltage which varies in amplitude to represent brightness through the image. The writer continues with the second method which he identified as digital method of processing image. In this case, supposed image will be change or converted to digital form through a device known as scanner digitizer for further processing.

Figure 2.1: sample digital image

Table 2.0: displays the dimensions of the digital image.

	Column 1	Column 2	Column 3
Row 1	128	30	123
Row 2	232	123	321
Row 3	123	77	89

Row 4	80	255	255

Each number in the table above represents the value of the function f(x,y) at any point. In this case the value 128, 230, 123 each represents an individual pixel value.

2.3.0 Image Processing Techniques

2.3.1. Image segmentation

(Ballard and Brown, 1982) defined image segmentation as the process of dividing or breaking an image into different parts based on certain characteristics. The parts usually conform to something that human beings can easily separate, view and analyze as individual objects. The digital computer as we know does not have the ability to recognize objects intelligently on their own; this is why different researchers have come out with different approaches and methods to segment images. Images are usually segmented depending on the various characteristics and features found in the image. These features may include colour information which is used to create histogram, information about pixels that indicate boundaries and texture information.

In the case of computers, image segmentation can be defined as the process of dividing digital image into several parts or components (a set of pixels that can also be referred to as super pixels). The purpose of segmenting any image is to simplify (make the image easier or less complicated) and change the representation of the image into something meaningful for the purposes of easier analysis. Image segmentation is usually used to detect and discover characteristics, objects and boundaries such as curves and lines in images. Image segmentation can simply be defined as the process of assigning some description to every pixel in an image to identify pixels with similar and unusual characteristics. The outcome of the segmentation process depends on a set of components that together the entire image or a set of outcome deduced from the image. Each of the pixels in a particular region is similar with respect to some characteristic or computed property, including intensity, texture and colour. Neighboring regions are significantly different with respect to the similar characteristics. When applied to a pile of images, typical in medical imaging, the resulting outline after image segmentation can be used to create3Dimensional reconstructions with the help of a written algorithm.

2.3.2 Image Thresholding

Image Thresholding refers to the process of creating a binary image (bitonal) by setting a starting point which serves as the base value of the pixel intensity of the original image. Thresholding technique is usually performed on grayscale images; however, thresholding may be applied to original (true colour) image. The threshold value of every image can either be set manually or automatically using a specific software or application. In this case, all pixels that fall below that set threshold value are converted to black which represents bit value of zero whilst any other pixels above the threshold value are changed to white representing a bit value of one. The thresholding can also be described as the process of breaking an image apart in order to get foreground values as well as background values (black and white). Thresholding can be simple or complex depending on the threshold value. Thresholding is said to be simple if there is only one threshold value set for all the pixels in the image for no matter the difference or variations in contrast. On the other hand, complex and sophisticated thresholding (adaptive thresholding) takes number of regions of the image and setthe threshold value accordingly. It should be noted that, quality cannot be compromised in thresholding especially when dealing with scanning images with Optical Character Recognition (OCR) systems. The simplest form of segmentation is by means of thresholding. This is because you only need to define a threshold then examine all pixels in the image by comparing them with the threshold value. All pixels found above the threshold value are considered as foreground, whilst the pixels located below the threshold value are considered as background. Oftenly, the threshold represents the intensity or the colour value of the image. Other forms of thresholding permit different or variable threshold values throughout the image. In this case, the threshold is permitted to undergo through several changes throughout the entire image. Thresholding is said to be a primitive technique because it works for most operations that need segmentation.

2.3.3 Image thresholding algorithms

There are so many researchers who have proposed different algorithms as far as image thresholding is concerned. This portion of the research seeks to discuss and analyze some of these algorithms as proposed by some researchers. In fact, choosing correct an appropriate algorithm is a difficult thing to do. This is due to the variation resulting from different algorithms since they assume differently about the content of the image. (Ridler and Calvard, 1978) conducted a research into plant diseases using image thresholding technique. They proposed an algorithm that uses iterative clustering approach to estimate disease severity on leaves. In their approach, they used an approximated threshold such as mean image intensity as the initial threshold value. Based on the initial value, they grouped the pixels in the image by assigning white to all pixels found above the threshold all below it are assigned black respectively. The threshold is repeated several times and reapproximated as a mean of the two class means. (Tsai,1985) proposed an algorithm that is used to determine thethreshold of an image by preserving the First three moments in the input image.(Otsu, 1979) proposed a paper that presented an algorithm that uses discriminant analysis approach to detect varied colours in plant leaves. This approach uses the zeroth and the first order cumulative moments of the histogram for calculating the threshold values. (Kapur et.al, 1985) presented an algorithm that measures the extent of deficiency of an image using the thresholding technique through an algorithm they proposed. This algorithm takes the threshold image as two different groups of events with each group represented by a Portable Document Format (pdf). This approach goes on to bring down the level of disorders that exist in the two pdfs thereby achieving a common threshold value. (Parker,1996)described two approaches which implemented the use of the entropy of the intensity histogram according to two definitions. These approaches were based on the method proposed by (Haung and Wang, 1995) and (Yager, 1997)of fuzziness. In another paper published by Rosin in 2011, he also proposed an algorithm that fits a straight line from the top or peak of the intensity to the last of it. The highest point of deviation that exists between the histogram and the line is usually found at the corner which is selected as the threshold value. The suitable and perfect algorithm fits a normal distribution to the intensity of the zxhistogram.

2.4 Measuring Disease severity on Leaves

(Pradnya R. Narvenar et al, 2014) presented a paper on the methods of detecting and analyzing leaf diseases using SGDM matrix method. In their research, several methods were revealed concerning methods of measuring leaf diseases.(Libo Liu and Ouomin Zhou, 2009)conducted a research on the methods of identifying leaf diseases in rice based on the characteristics of the colours of leaf lesion area using the thresholding method. (Vane Zhang, 2005) conducted a research on cucumber in order to determine the methods of diagnosing the nutritional status of green crops usingmachine vision technology. The result showed a mutual relationship betweenthe green components andothercolour componentsof the leaves with the nitrogen which could be used rapidly asdiagnosis of crop diseases indicator under the same conditions. (Chunhua Hu et.al, 2004) used two different statisticstical features of the ROB system to distinguish between the deficiency cucumber blades, using features of the Ohta system. The system was used to identify the colour of different cucumber leaves and obtain the Hue (H) relative percentagehistogramof Hue Saturation Value (HSV) colour system in order to calculate the extent of deficiency in leaves. This algorithm was believed to have been successful.(P. Revathi, et.al, 2012) detected spot disease on cotton leaf using a technique known asIEDS (Image Edge detection Segmentation). In the IEDS technique, the captured images are first processed for enrichment. Afterwards,the image was segmented using Red, Green, and Blue (RGB) colour feature to obtain targeted regions (disease area). They finally extracted certain features including image boundary,image shape, texture and colour to identify diseases and control the pest on the leaves.

Kim et.al alsousedcolour texture features analysis, to categorize the diseases in grape fruit peels in their research. In their paper,they used SGDM to estimate the texture features. Their method for classifying the peels was through squared distance technique. There are several diseases that affect grape fruit peel including copper burn, melanose, wind canker and greasy spot. Helly et.al also used the HIS transformation method to segment an image. In their method, segmentation was done through fuzzy C mean algorithm. The purpose of this method was to obtain features like colour, size and shape of the spot and classify them by means of neural networks. According to them; the accuracy of this classification method was 97%.(Al-Bashih et.al,2011)used a fast and accurate method to detect diseases in leaf by k-means classification method. The images were segmented using neural networks based classification. High resolution multispectral and stereo images were used to automatically classify leaf diseases. (Sabine D. Buar et.al, 2011) used weighted Parzen-window Segmentation process to obtain a threshold value to deduce the diseased region on plant leaves.They graded plant diseases by calculating the quotient of disease spot and leaf areas.(Zulkifli Bin Husin et.al, 2012) used the colour clustering method to detect leaf disease in chilli plant through Graphical User Interface (GUI).(Yinmao Songet.al, 2012, developed methods to detect crop disease through image processing technology. Their method was used to extract features like colour, shape and texture and their respective problems were identified after segmentation. (Keru Wang and Shaokun Li, 2006)used machine vision technology to determine the amount of chlorophyll in cotton leaf using colour features on the leaves. Their research shows the coordination between b and b/rin the BIR values of ROB colour system. The chromaticity coordinates and the S values of HIS colour system were all greatly related with chlorophyll content of cotton leaf. Hence, these values could be used to determine the amount of chlorophyll in the leaf.

In a paper presented by Brendon J. Woodford et.al entitled "Fruit Image Analysis using Wavelets", a new method of processing images was proposed using neural network and wavelet technique to develop a method of identifying the level in pip fruit as caused by pest in the fruit. They conducted the research based on three most frequently pests found in orchards. These include the leaf-roller, apple leaf curling midge and lastly codling moth. The important features in the fruits were extracted using a fast wavelet transform with special set. They used two important steps to search and retrieve the related images. First, the images were matched by comparing the three colour components (RGB) by computing the standard deviations for each.In the second step, a weighted version of the Euclidean distance between the feature coefficients of the images was selected from the first step. That was followed by calculating the final coefficient of the image. They then selected all the images with the shortest distances and grouped them at one side and those with longest distances were also grouped at another side.

Finally, images with shorter distances were considered as matching images to the query. (Mixand Pico 2003) used Stereomicroscopic method and Image analysis technique to measure features like size, shape, and dispersal related structures in fruits. Their method is considered as one of the simplest, precise and efficient ways of analyzing and comparing images. It was generally revealed that, obtaining the length of fruit through the image analysis approach was significantly greater than the one been recorded with a stereomicroscopic means. It was determined that the only thing that did not differ between the two methods was the estimation of the fruit length. In spite of that, there was a great significant relation between fruit length estimates obtained from both methods for all species of study. The results proved, estimating fruit length using image analysis and stereomicroscopic approaches produced similar results by discriminating accurately fruits of different sizes. But it was concluded that image analysis has the following advantages:

1) The high amount of fruit parameters obtained with one single measurement
2) The method reduces human error
3) The method also helps in saving time
4) It also provides the opportunity to estimate the varied characteristics of which have complex shapes, diseased leaves and other traits that have outward effects on plants like rolling the leaves or destroying the whole plant.

(AlhasanandUmer, 2004) conducted a research to find the possible ways of detecting outward effects of fruits, leaves and other traits mentioned in the study conducted by Mix and Pico using several remote sensing methods to acquire spectral image taken by airplanes, satellites and other sophisticated methods. (Gamaland Reda Abd Ei Wahab, 2004) proposed a different approach for integrating image analysis technique into diagnostic expert system.They used an Expert System (CLASE) based on agriculture to monitor cucumber crop. The expert system was used to detect diseases in the cucumber plant. They used four different image processing phases to diagnose several disorders from leaf images. These image processing phases include the following:

1. Image enhancement
2. Image segmentation,
3. Feature extraction and
4. Image classification.

Their method was used to test Leaf miner, Powdery and, Downey as different disorders in leaves. Their system was successful because it reduced errors that exist between systems and user during a dialogue. The structural features of leaves were used for classifying plants and also diagnose certain diseases in plants early enough. Their method was used to detect three different disorders including, Leaf miner, Powdery and, Downey. Their system was successful because it reduced errors that exist between systems and users during a dialogue. The structural features of leaves were used for classifying plant diseases and also diagnose certain diseases early enough to avoid the spread of such diseases to other plants.

(Panagiotis Tzionas et.al, 2005) presented a paper on design, implementation and testing of an artificial vision system that can be used to deduce distinctive geometric and structural features from plant leaves from plant leaves. Their system was based on machine vision using camera in combination with algorithms for processing images. (Rakesh and Amar, 2006) proposed a new technique for selecting features of plants using Fuzzy Surface Selection Technique to extract certain features from various plants. They used a support vector machine as their method to develop a system that predicts plant diseases based on changes in weather conditions. Their approach was used to compare the effectiveness, competence and performance of artificial neural network, conventional multiple regression, Support Vector Machine (SVM). They concluded in their paper that, Support Vector Machine (SVM) which is based on regression approach has given the best way of explaining the similarities and differences between the environmental conditions of the plants and disease levels which could be used to manage plant diseases.(Prasad Babu et.al, 2007) suggested a new approach known as back propagation neural network for recognition of leaf diseases. Their research proved that only the back propagation Neural Network and shape of a leaf is enough to specify the species of a leaf. This method was base on a technique known as Prewitt edge detection and thinning algorithmto determine leaf tokens as an input to back propagation algorithm. Their method was successful but needed much experimentation obtain the results needed. This however, made it somehow cumbersome and complex.

(Alexander A. Doudkin et.al, 2007) also suggested neural network technique for segmenting agricultural landed fields in remote sensing data. They used neural network algorithm which was based on back propagation method to segment the colour images of fields that have been infected by diseases that leads to unusual colour changes in plants. (Stephen Gang Wu et.al, 2007) implemented a simple and easy to use leaf recognition algorithm using simple features and high performance recognition algorithm. Their method was based on a Probabilistic Neural Network (PNN) which was used to recognize the leaves of the plants. The various features were extracted from the images and later processed using features are extracted and processed by Principal Component Analysis to form input to the Probabilistic Neural Network. Their algorithm was estimated to have carried an accuracy of 90% on different plants. (M.T. Maliappis et.al, 2008) presented a paper that explains how computers can be used in agriculture to management the process of cultivation in low-tech greenhouse. They implemented the system as a web-based application that included open source technologies and other smaller systems (sub systems) to provide four main importance in agriculture including the following:

1) Production of information about the cultivation process and means of marketing the supported crops.

2) The possibility of simulating and forecasting the models of interest.

3) Means of collaboration environment and

4) Availability of Expert system capabilities and support.

The Expert System was a modification of the VEGES Expert System expert system which was originally issued as a web based application to identify pests, diseases and nutritional disorders. (Santanu and Jaya, 2008)proposed a software prototype system which could be used as a means of detecting leaf disease infections in rice plants. The software was based on images obtained from the infected leafs. They used image segmentation techniques to detect infected parts of the plants. They used an algorithm known as zooming algorithm to obtain specific features like shape, color and length of the images. Their approach was based on a method known as Self Organize Map (SOM) Neural Network which was used to classify the rise in diseased images. (Weizheng S. et.al 2008) presented a fast and accurate novel method in a similar way which is image processing based technique for grading of plant diseases. They used the Otsu segmentation method to segment leaf regions. The plant diseases were estimated by calculating the quotient of the areas affected by the disease.

(A. Menunkaewjinda et.al 2008) also used hybrid intelligent system to detected colour imagery in diseased Grape leaf. Their system was based the Self Organizing Map and back Propagation Neural Network. The proposed system was able to recognize colours of grape leaf. They used the information that is deduced from the method to perform segmentation on the pixels found in the images of grape leaves. Finally, the segmentation process was performed on the diseased leaves using a modified form of the Self Organizing feature maps with an algorithm based on genetic features. The genetic algorithm was used for optimization whiles the Support Vector Machine was used was for classification.(Geng Ying et.al2008) proposed another method of processing images to recognize diseases in crops using machine vision. Their study samples were chosen from cucumber powdery mildew, spackles and downy mildew. The samples were used to report comparative effects is simple images.(Xinhong Zhang and Fan Zhang, 2008) suggested another method of processing images through machine vision techniques to automatically inspect flue-cured tobacco leaves. The purpose of the Machine Vision technique in this system is to deduce, analyze and curb the deficiencies associated with tobacco leaves. These deficiencies include colour features, surface texture, shape and size. The outcome of their experiment showed that the system is an efficient and easy way of extracting various features from tobacco leaves. It can also be used to automatically classify tobacco leaves as well as other leaves from other plants that share similar characteristics.(Xu Pengyun and Li Jigang, 2009) presented a paper that gives methods to monitor spores caused diseases in plants. They first converted all original images (colour image) into gray scale image in order to perform the analysis and processing of the image. The analysis and processing that took place include generation of histogram, correction of gray level, extraction of image features and sharpening of the image. In order to remove frequency components of the low level, they used edge algorithm together with Median Filter to convert the input gray image through edge enhancement. After thresholding, they used structural (morphological) features such as dilation, erosion and opening to process the resulting image. It was concluded that, this method can be used for many works such as counting and monitoring of plants diseases under microscope, chromosome counting and optics stripe counting. (Qing Yao et.al, 2009) presented an efficient and accurate means of detecting diseases that affect rice plants in their early through the use of image processing techniques and the Support Vector Machine. (SVM).The spots identified on the rice plants were segmented to extract features like shape and texture for further processing. Due to the swaying of the colour features by the sources of light from outside, they decided to use features like shape and colour texture features of the diseased spots as characteristics values of classification. The purpose of the support vector machine in this approach was to group and arrange rice plant diseases such as rice bacterial leaf blight, rice blast and rice sheath blight. They concluded that, the Support Vector Machine is the most simple and efficient way of detecting and classifying these diseased spots to an accuracy of 97% in rice plants. (Di Cui et.al, 2009) suggested a new approach of detecting and classifying diseases in plants accurately. Their method was based on three principal approaches including the K-means clustering, Otsu Segmentation and Back Propagation Feed Forward Neural Network Method. The results of their experimentation were to cluster and classify diseases that affect plant leaves.

(Di Cui et.al, 2009) proposed another methods for detecting and quantifying severity of soybean rust. In this method, the authors collected different images of soybean leaves that have been affected with different levels of rust severity through portable spectrometer and multispectral CCD camera. They focused on three principal areas including percentage of area been infected, lesion colour index and rust severity index. This method was used to quantify the severity of diseases in the soybean images they collected.

2.4.0 Methods of Quantifying Leaf Disease Severity

There are several methods used by various researchers to quantify leaf disease severity. Some of these methods are discussed in this paper. Plant leaf disease can be estimated and quantified either by the area been affected or by the extent of which the disease has been rooted (how deep the affection is) on the leaf that can be estimated through features like colour and texture. Most of the techniques and algorithms used to quantify disease severity include a segmentation step to separate the symptoms in order to extract features and properly process the features to achieve an estimate for the severity of the disease. This paper classifies the strategies and methods used by other researcher based on the specific approach used to estimate the disease severity. Such strategies and approaches include thresholding methods, colour analysis, Fuzzy Logic, Neural networks, Knowledge Base Systems (KBS), Support Vector Machines (SVM) and third party application packages.

2.4.1 Thresholding Method

(Lindow and Webb,1983) quantified plant leaf disease using the thresholding approach. They captured the images under red light using digital video cameras. The purpose of the red light was to highlight the necrotic areas of the image. The images were later converted into digital form. The tests were performed using leaves from four different crops namely tomatoes, bracken fern, sycamore and California buckeye. Simple thresholding method was used to identify the necrotic regions. Their algorithm was further used to apply a correction factor to equally balance the pixels from the healthy regions based on the variations in the colour features of the leaves so that it will be easier to identify all of the pixels that were wrongly counted as part of the diseased areas so that they can be classified to their proper and correct regions. (Tucker et.al, 1997) used a thresholding algorithm to identify and estimate leaf diseases in some plants including sunflower and oat. In the first stage, the algorithm was used to segment the images with varied threshold values depending on how the disease is considered (blight or rust). The pixels obtained in the segmentation process were associated into groups depicting the regions affected by the disease. Based on the attributes and characteristics deduced from the lesion areas, they further classified the lesions into two categories; either category a or category b depending on the exhibited characteristics. This approach was reported to be one of the best methods ever used to estimate leaf diseases. However, it recorded some wrong results due to inadequate lighting system at the time of capturing the images. (Martin et.al, 1998) suggested a new approach of determining and quantifying the symptoms caused by the maize streak virus. Their method was based on an earlier research conducted by Lindow and Webb in 1993. They used a software package to visually compare the results. The results showed that both the commercial off the shelf and costumed applications had almost the same functionalities and efficiency; hence the two methods through computers produced the same output in terms of accuracy and precision as compared to the visual approach. (Weizheng et.al, 2008) proposed a new approach of detecting and estimating leaf disease on soybean using multiple algorithms. They used an algorithm based on two-step algorithms. The first threshold was intended to separate the leaf portion from the background image. After that, the image is then converted into HIS colour space where the Sobel operator is used to estimate the diseased area. This is followed by the second threshold where the threshold is applied to the results obtained from the first threshold. Finally, the objects in the binary image will be discarded filling all the holes enclosed by white pixels. The resulting objects showed the diseased regions. (Llret et.al, 2011) proposed a new system to and monitor the conditions of health in vineyards. They used cameras to acquire the images by spreading the cameras all over the field. The reason for doing that was to detect measure and quantify diseased leaves. They used five different steps to achieve the desired results. The first stage aims at estimating the size of the leaf which is an important step due to varied distance between the cameras and the plants. The second step is the application of thresholding technique to separate the healthy leaves from the diseased ones from the ground by representing the images in Red, Green and Blue (RGB) and HSV forms. This is followed by a set of structural operations which aims to reduce noise but maintaining important and useful features without eliminating them. The fourth step is used to detect and separate the ground from actual diseased leaves. Finally, the diseased ratio is estimated based on the results of the entire image ratio. The system gives a warning that the plant requires some attention if any fault is detected based on the ratio.

2.4.2 The use of Color Analysis

Color Analysis in plants is the process of analyzing the color of plant leaves using color patterns. This method was first developed by John Wolfgang von Geothe (1749-1832), a German Professor philosopher. He used color analysis to determine the differences between different colors and created a color psychology out of his findings. Since then, color analysis has become popular in many fields of academia. Johannes Itten, (1888-1967), a Swiss expressionist painter, teacher, writer and theorist also used colour analysis in most of his art works throughout his career as a professional. This made color analysis more popular and interesting. Currently, color analysis has become a field of study and is more useful in diverse ways including image processing.

(Pagola et.al, 2009) suggested a new system to estimate the level of nitrogen deficiency in plant leaves associated with the barley plant. The proposed system was based through different colour media by applying the Principal Component Analysis approach (PCA) to measure the amount of chlorophyll content in the leaves. To achieve correct and accurate results, the authors performed four different tests using different strategies with the intention of emphasizing on the relevant and ignoring the negative effects of the less important areas that are photosynthetically inactive. Such regions include the veins and areas with spot on the leaves. They stated in their conclusion that, their method had high relationship with the other approaches that are largely adopted based on non-destructive hand-held chlorophyll meters.

Contreas-Medina et.al, 2011) developed a system that could be used to detect and estimate at least five types of symptoms associated with plant leaf diseases. The proposed system comprises five different independent modules. First, the red and green components of the image were combined using Chlorosis algorithm with the intention of determining the yellowness of the leaf which is a symptom of Chlorosis. That is followed by a Necrosis algorithm to differentiate between the leaves and the background through the blue component in the image. The third stage uses the blue to segment and calculates the level of deformation in the leaf through deformation algorithm. The next step applies thresholding on the blue component to calculate the ratio of the diseased area using white spot algorithm. Finally, several types of the venations in the leaves were identified through mosaic algorithm, canny edge detector, and other morphological operations.

2.4.3 Using Fuzzy logic

Fuzzy logic in computing is a procedure based on degrees of truth instead of depending the on Boolean logic which deals with the usual true or false which is the method used by modern computers. Dr. Lotfi Zadeh, a Lecturer of University of California in the early 1960s first advanced the idea of fuzzy logic when working on the computer's understanding of natural language. Fuzzy logic has been so beneficial in computing in many ways including artificial intelligence and image processing.

(Sekulska-Nalewajko et.al, 2011) developed a system to identify and estimate symptoms of some disorders in pumpkin and cucumber leaves. The authors used flatbed scanners to acquire the images for the experiment. They first separated the leaves from the plants, treated and stained them before they were captured. They then implemented their ideas based on functions present in the matlab toolbox. They initially separated the leaves using thresholding algorithms. That was followed by converting the image HSV colour space from RGB space. The brightness component of the image was discarded. Then, the pixels were grouped into two main clusters using Fuzzy c-means algorithm. This grouping represents the healthy and diseased regions. The authors in their conclusion stated that, their system is a simple and efficient way of estimating plant diseases as compared by other methods that according to them need several operations to achieve the desired results.

(Zhou et al, 2011) in a related research conducted by Zhou et.al in 2011, a new method was proposed to examine the degree of grass hopper infestation in rice crops. They focused on the stem of rice plant because the-hoppers extremely manifests in the stem. In the algorithm they first extract the region of interest then fractal-dimension value features are extracted using the box-counting dimension method. These features are used to derive a regression model. They finally classify the regions into four (no infestation region, mild infestation region, moderate infestation region and severe infestation region) using a fuzzy C-means algorithm.

2.4.4 Knowledge-Based System

Knowledge Base System is an aspect in artificial intelligence that uses database of a subject to solve complex problems. It is basically an application that uses artificial intelligence and expert system technique in problem solving.

(Boissard et al, 2008) presented a paper that describes a method to estimate the severity of plant disease in some plants as a method of detecting early pest in the pants. They used two separate knowledge-based systems (KBS) to estimate the number of insects. The first system was based on Classification Knowledge Base System (C-KBS), which takes results from the numerical image processing operations and translate the numerical results into higher level concepts which are then examined to assist the algorithm to choose and keep only the regions that contain insects. Their second system was also based on Supervision Knowledge Base System (S-KBS) which served as a means of selecting the appropriate image processing tools to be applied as well as the constrains to be used in order to collect and feed the most meaningful information to the first system. Even though they achieved some good results, they concluded by stating that their proposal had some problems which were not mentioned and addressed.

2.4.5 Third party image processing packages

(Bock et.al 2008) proposed a system to detect and quantify the severity of Foliar Citrus Canker in the leaves of grape fruit. They used software known as Assess V1.0 to perform analysis on the image. Finally, they used Image Analysis Software to quantify plant disease. (Peressotti et al,2011) used a software package known as ImageJ to detect and estimate downy mildew sporulation in grapevine. They developed a special application (macro) for ImageJ, which was used to gradually change adjust colour balance and contrast found in the image before presenting the image to the user. Users can then use that to test for so many different threshold values to segment the image until the desired results is obtained. They concluded by reporting that, their method has similar results as other methods and that of the visual assessment.

2.4.6 Using Neural Network

Neural Network is an Artificial Intelligences system that seeks to imitate the human brain.

Neural network was first developed in the early 1950s by Bernard Widrow of Stanford University. Neural network s is used in various fields in computing most especially in voice recognition systems, image recognition systems, robotics, medicine etc.

(Pydipati et al, 2005) detected and grouped some diseases in citrus plants using two different approaches. They gathered features like shape, colour, texture and size and created four different smaller groups of those features and classified them by two approaches. They used Mahalanobis minimum distance classifier in their first approach together with a principle known as Nearest

Neighboring Principle to detect the diseases. The second step was the classification stage where they used Radial basis Functions (RBF) Neural Network Classifiers together with the back propagation algorithm to group the plants based on similar characteristics. They concluded by stating that both classification approaches produced equal results.

(Sanyal et al, 2007) detected and classified six different mineral deficiencies in rice plant using neural network. They first used an algorithm to obtain some characteristic features like colour and texture from the plants. The features were individually submitted to their own specific Multilayer Perception (MLP) using Neural Network. The two networks have a common hidden layer, but the number of neurons in the hidden layer is different depending on the feature submitted to it; (40 for texture and 70 for colour). The results produced by the two networks were combined for the purpose of the final classification. They also used a similar method to detect leaf disease in 2008 but in this case, their aim was to identify two kinds of diseases including blast and brown spots that affect rice crops.

2.4.7 The use of Support vector machines (SVM)

Support vector machines are Learning models associated with learning algorithms that analyze data with the intention of classifying and analyzing objects. They are discriminative classifiers based on decision planes that define decision boundaries.

(Youwen et al. 2008) used an algorithm based a statistic pattern recognition to identify some diseases that affect cucumber leaves. The algorithm was used to segment the leaves into healthy and diseased regions. That is followed by extracting colour, shape and texture features from the image. The final classification is done by feeding the features into the SVM. They concluded by stating that, Support Vector Machine produce better results than Neural networks based on their experimentation. (Camargo and Smith 2009) also tried to detect and measure the extent of defect in cotton plants. Images were captured from the stem, leaves and the fruits of the cotton plant for the experiment. They segmented the images using a technique they had already developed earlier which was described in this paper under Thresholding. They then extracted several features from the diseased regions. Those features are then used to feed the SVM for detection and estimation of the diseased portions of the images. (Jian and Wei,2010) presented a paper that uses the SVM to detect cucumber leaf diseases. They used the simple thresholding method to segment the healthy and diseased regions of the leaves. That was followed by extracting features like colour, shape and texture from the image for further processing. Those features are fed into the SVM with Radial Basis Function (RBF) as kernel, which performs the final classification.

2.4.8 The use of Fuzzy classifier

(Hairuddin et al, 2011) used the fuzzy classifier to detect some deficiencies in oil palm plant. They captured images and segmented them based on specific characteristics mainly similarities in colour. However, they did not make available the procedure for doing that in their paper. . After the segmentation process, they obtained features like colour, and texture and processed them further by feeding them to the fuzzy classifier which suggests the amount of fertilizers to apply on the plants to correct the deficiencies instead of revealing the type of deficiency detected in the plant. Unfortunately, the technical details available in this paper are shallow, making it difficult to get a clear understanding about their system and approach.

Chapter Summary

The chapter covered the analysis and revision of papers, books, publications and other materials and sources related to the study. Materials written by other persons or authors in context with the topic were considered.

The major items including topic and sub-topics discussed include the definition, origin and uses of image processing, image processing methods in relation to disease severity and effects of fungi caused diseases on plants.

Major items considered in the chapter include:

1. **Image processing**: Image processing is the process of improving and enhancing raw images received from cameras placed on satellites, sensors, space probes and aircrafts or pictures taken in normal day to day life for various applications.
2. **Uses of image processing:** these included detection of diseased stem, leaf and stem in plants, quantification of diseased area in leaves, detection of shape and size of fruit, etc.
3. **Image processing methods:** these included analog and digital methods.
4. **Image processing techniques:** some of these included image segmentation and image thresholding and methods of detecting and measuring diseases on plant leaves.
5. **Methods of identifying and quantifying diseases:** these include thresholding, colour analysis, neural networks, knowledge base systems, fuzzy logic, support vector machine, etc.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter takes into account the principles, procedures and methodologies used to achieve the expected results and outcome of the research. These procedures include includes the procedure for acquiring the images, methods of segmenting and thresholding the image, and algorithm to measure the severity of the diseased area of the leaf through the image.

3.1 Materials used for the project.

The following tools and materials were used for the project; Sample spot infected plant leaves, 20 samples, Digital Camera, black sheet/cloth, Light System, computer and MATLAB software Version R2015a.

3.2 Principles and methods

Three principal stages are involved in undertaking this project. These include image acquisition, image segmentation and finally leaf region segmentation. However, other principles like conversion of image into various forms were also considered.

A. Image acquisition

Suspected plant leaves are used to carry out this project. The digital camera was used to capture images in controlled environment with the dark background. The images were stored in either JPEG or PNG format. First, the diseased leaf was placed flat on the black background (black cloth) with correct amount of light sources. This was to eliminate any reflection and get light evenly distributed everywhere in order to get a better view and brightness of the image to be processed.

The object (leaf) was properly zoomed using the digital camera to ensure that the picture taken contained only the leaf and black background with the rightful image size.

B. Image segmentation

The segmentation step was used to separate the image into different regions based on similar characteristics in the image. These regions show distinct and unique characteristics from one another and should not intersect one another. Each of the regions should portray some level of consistency in the region. The segmentation stage went through two different stages in order to obtain total leaf pixels and the pixels in the leaf lesion area.

For the purposes of proper segmentation, the image is converted to grayscale from the RGB format. This can be achieved by finding the average of the three colour components in the true colour. First get the supposed image, extract the red, green and blue values of pixel using their corresponding numbers and finally replace the original RGB values with the new values. The conversion is done by computing the average of the three.

Figure 3.0: sample true colour image

If you have any color image like the image shown in figure 3.0 above and you want to convert it into grayscale using average method, the following result would be achieved as shown in figure 3.1

Figure 3.1: gray scale of figure 3.0

One thing is that, the average method does not give accurate results even though it works perfectly. This is due to the fact that this method computes the average of the three colours. Since the three colours have different wavelengths and contribute in the formation of the image, they produce inaccurate results. This can be corrected by computing the average based on the contribution made by each colour in the image.

Mathematically, this can be expressed as:

G1= (R+G1+B)/3 where

G1= gray, R=red, G2=green and B=blue

Hence, Gray= (Red + Blue + Green) /3

Algorithm to achieve this is stated below as

For each pixel in image {

Red =pixel.Red

Green=pixel.Green

Blue = pixel.lue

Gray =(Red+Green+Blue)/3

Pixel.Red=Gray

Pixel.Green=Gray

Pixel.Blue=Gray

C. Leaf region segmentation

To perform the segmentation process, the image was first converted into grayscale from the true colour. This helped in differentiating due to the variation in the gray values of the two (background and actual image). The background colour if the image was represented as black whiles the actual image was represented as white. After image segmentation, the binary image containing leaf region is obtained by region filling and removing every hole in the white region. The image is then scanned from top to bottom and from left to right using the MATHLAB software to determine the total the number of pixels in the leaf.

D. Diseased region segmentation

To achieve the accurate results, there is the need to segment the image to obtain only the diseased area. If proper care is not taken, segmentation may be wrong because of colour variation. If the central vein of the leaf (midrib) is shallower than that of the actual leaf, it may lead to inaccurate results. Also, because leaf diseases go through different stages of the disease due to factors such as water, light and neutrino, the lesion shows various symptoms, which makes the segmentation process difficult. Considering the factors mentioned, it is better to convert the image to HIS colour space from the RGB colour space to make it visible to the human eye. The human eye is more sensitive to hue images as compared to saturated images, due to that the image was converted to the saturation form. This is due to the fact that, the brightness component in the image is independent of the human eye therefore that makes it easier to remove shadow, glare and other light factors during colour image segmentation. To a large extent, the similar gray value of the shallow colour of the midrib and the leaf colour component can decrease the interference of the midrib in the lesion image segmentation. If the lesion characteristics are varied, then the boundaries between the lesion and the healthy parts are also varied and creates a weak edge. That called for the triangle thresholding method as the best approach for achieving the desired results for this project.

Algorithm

1. *Check to ensure that the user has installed Image processing Toolbox in Matlab.*
2. *Load the image into Matlab (with full file location)*
3. *Get the dimensions of the image*
4. *Convert the image to HSV color space*
5. *calculate the black pixels*
6. *Find only the black that is outside the leaf, not inside the leaf*
7. *Mask the H, S, and V images*
8. *Plot the histogram of the hue area*
9. *Call anything with a hue of between 0.15 and 0.5 "healthy".*
10. *Call anything else (that is not background) "diseased."*
11. *Compute the diseased area fraction*
12. *end*

Mathematically, algorithm for estimating diseased severity can be expressed as:

DS = DA / TA……………… (1)

= P Σ1 / P Σ1

(X, Y) Є DR(X, Y) Є LR

= Σ1 / Σ1

(X, Y) Є Rd (X, Y) Є Rl

= Pd / Pl…………………….. (2)

Where,

DS = Disease Severity,

P = Unit pixel value,

DA = Diseased leaf Area

TA = Total Leaf Area,

DR = Diseased Region,

LR = Leaf Region,

Pd = Total pixels in Diseased Area, Pl

= Total Pixels of the Leaf.

Every pixel in the image has equal value therefore it is easier to extract the diseased portion by counting the numbers in the region and express it in the ratio of the total leaf area as shown in the algorithm above.

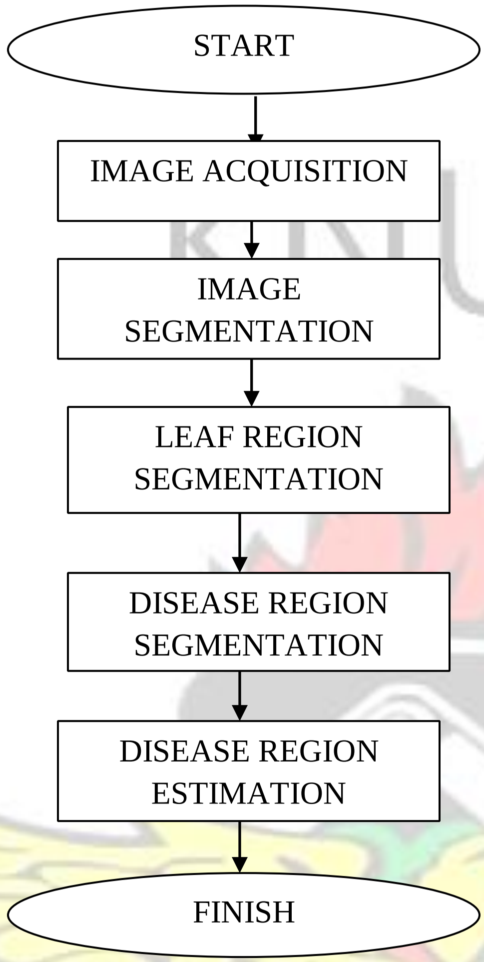


Figure 1: The figure above represents all the stages to go through in order to achieve the accurate results of this project.

CHAPTER FOUR

RESULTS AND IMPLEMENTATION

INTRODUCTION

The purpose of this study is to measure the severity of fungi caused diseases on leaves using the triangle and simple threshold methods. This chapter seeks to present the results of the study by analyzing and interpreting the data collected for the study. Different strategies were put in place in order to have a better representation of the results. For the sake of easier and better reading and understanding, the results were presented using tables, charts, diagrams, percentages etc. . To achieve the accurate results, four samples of leaves affected by fungi were captured using a digital camera with a dark background. These four samples were used for the initial experimentation. Later, several samples were used to test the system after it proved to be efficient. This was done to ensure proper and accurate results. These samples have been captured and represented in appendix **A** of the paper.

Figures4 A-D represent images of leaves affected by fungi showing the true colors of the images.

Figure 2, Sample A

Figure 3, sample B

Figure 4, Sample C

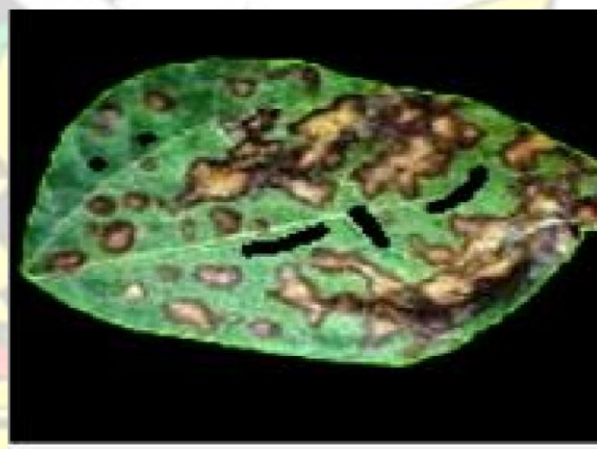


Figure 5, Sample D

The Figures 4D-D represent samples of images captured with digital camera for the purpose of this study.

After taking the images, they are then converted into various forms such as hue, saturation, gray scale, background pixels for proper segmentation using thresholding methods to extract meaning from them.

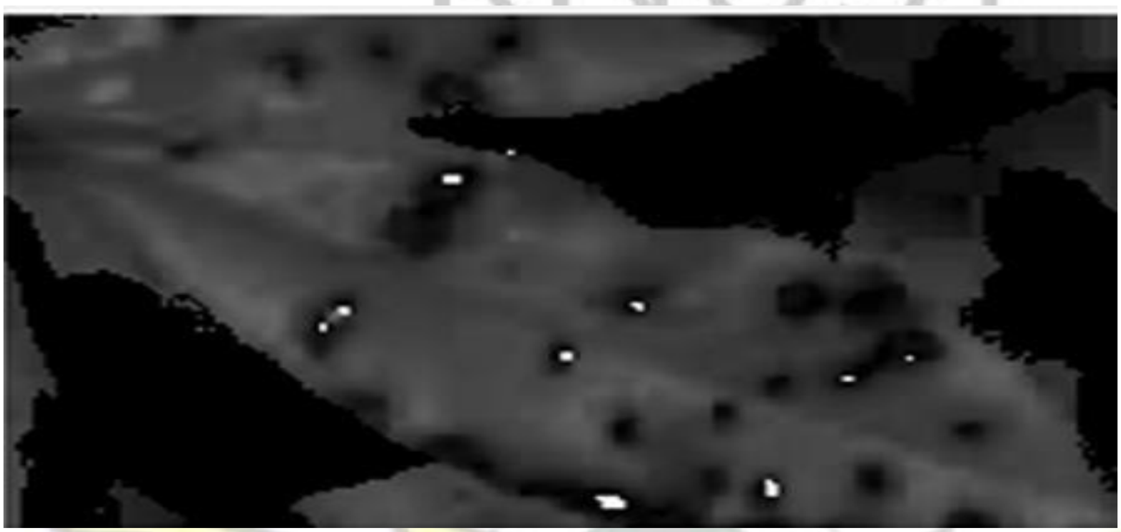


Figure 6: the Figure above represents the hue form of sample image A

Hue is defined as a colour attribute that describes the pure colour in an image. Most often than not, hue is described in terms of colour components such as red, green, and magenta. It is also used to separate combination of two pure colours like Red- which gives orange or yellow green. Hue is usually one of the three properties used to determine a certain colour. Hue is one of the more technical means of defining colour perception which can be used to communicate colour ideas. Hue can therefore be used to set original/true colours within a set of colour in a particular colour space. It can be set from zero to 356 when measured in degrees.

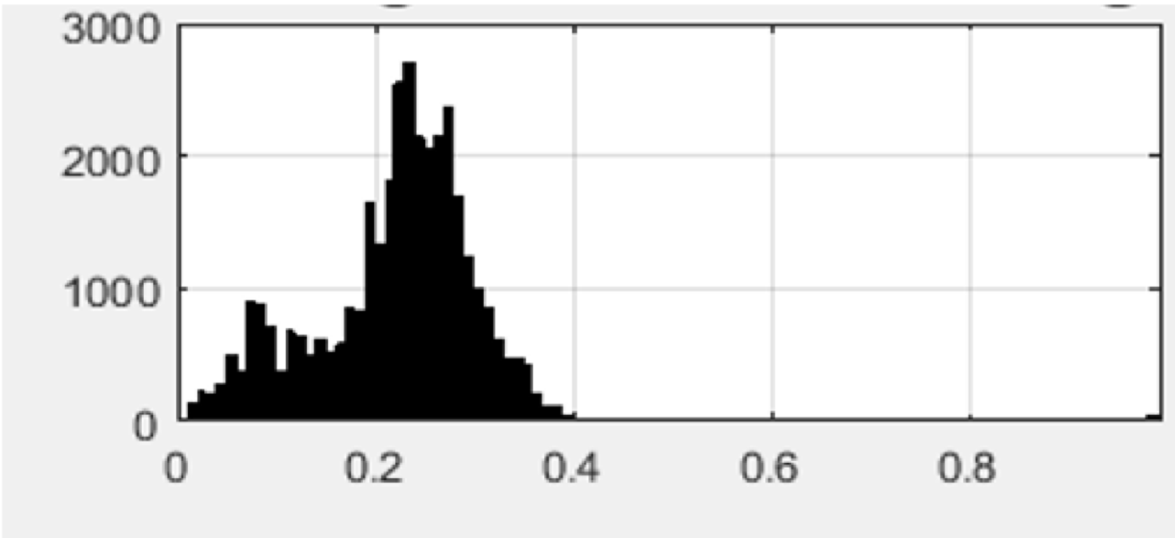


Figure 7: the Figure above represents the histogram of the hue form of the image

A histogram can simply be defined as a special graph that categorizes the colours of the pixels within an image into permanent and stable bins whereby each of the categories extends some small range of values. In each instance, each of the bins contains a number of colour levels (pixel values) in the image that fall into the range. The outcome of this represents the extent at which the colour values that make up the image are distributed. This distribution is formed from left to right with black pixels at the left and white one at the right. Histogram results are usually displayed in a form of bar chart. However, it can also be represented in the form of line graph but in this case; the lines must be connected to the top of the bars. This is done by using the IM toolkitto obtain a special histogram output format. The actual height of a histogram chart has little actual meaning because the charts are usually scaled so that the highest peak touches the top of the image. Therefore, the height of each individual bar is irrelevant. What is much more important is the distribution of the histogram over the whole range, and how the relative heights relate to each other over the whole of the chart.

It is always better to consider the following factors when reading histogram charts in imaging.

1. Check whether the histogram forms one wide band of values or it has a tight group in the middle or at any of the ends. When there is only one band of values in the image, it implies the image makes wide use of the color space and thus has good contrast. Also, the presence of thigh group in the middle or any of the ends means thethe image has a low contrast, making it look 'fogged' or 'grayed', or perhaps overly light or dark.
2. Ask yourself whether the histogram forms two or more peaks a due to highly different areas or regions in the image.
3. Identify where most of the pixels are. When they are found at the left, it means the image is very dark. On the other hand, when they are found at the right, it implies the image is very bright is very bright.
4. Examine the histogram to see if there are regular spaces or gaps between the individual bars. When this happens, it implies that the image has very few pixels in it and therefore could not be used to fill out the whole histogram, or the image was colour reduced or modified resulting to the gaps.

The use of histogram is very important in image processing because it presents the image in simpler form. This makes it easier to change or adjust an image in terms of its histogram. It must be noted that every mathematical colour transformation that is applied to the image will result in modification of both the image and its histogram. These include both linear and non-linear operations.

Figure 8: the Figure above represents the black pixels of image sample A

The dark portions of the above image represent the total leaf area captured by the digital camera whiles the white portions represent the spaces between the image.

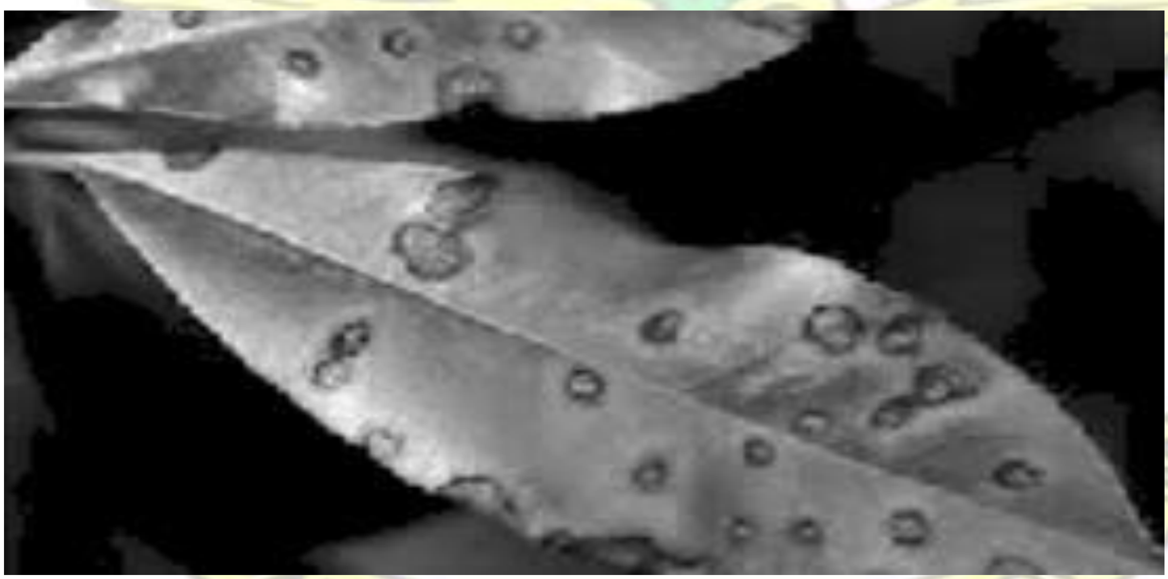
Figure 9: above this represents the saturation image of sample image A

Color saturation in image processing and graphics is used to describe the intensity of color in a particular image. A saturated image has overly bright colors. The more saturated a colour, the more vivid it appears to be. The less saturated a colour is the closer it is to grey. There is no right or wrong answer to how saturated colours should be in an image; it largely depends on how you want your images to look. When there is too much saturation in an image, the image looks like a cartoon. It is also difficult to accurately print images that are too saturated. However, an image which is less saturated (desaturated) is also said to be dull, less colorful or washed out but can also make the impression of being softer. The image (A) was converted into saturated form to determine the intensity of color in the image.

Figure 10 above represents the healthy portion of sample A

Figure 10 above shows the healthy portions of image sample A where the white areas represent the healthy portions of the image sample.

Figure 11 above represents the background pixels of sample image A.



Figure, 12: this Figure represents the value image of sample A

In image processing, value is defined as the extent of lightness or darkness of a colour in an image. It is an important tool in image processing because it defines form and creates spatial illusions. It must be noted that contrast of values in an image separates objects in space, while gradation of value in an image suggests mass and contour of a contiguous surface.

Figure 13: this Figure represents the diseased portions of image sample A

Figure 13 above shows the diseased portions of the image. The portions with white colours represent the affected areas of the image.

After the various forms of segmentation, the percentage of area affected by the fungi is then calculated using the algorithm in **appendix B**. The MathLab codes were used to determine the severity of the diseased area of the leaf. This algorithm is used for the segmentations as well as calculating the diseased portions of the image by counting all the pixels in the diseased region during thresholding and expressing them in a ratio of the total pixels in the image. The result is then expressed in a percentage of 100.

Finally, the area fraction affected by fungi caused disease on image sample A was estimated to be**20.10%.**

The same procedures were followed to determined image samples **B, C**, and **D**. the final results obtained are shown below:

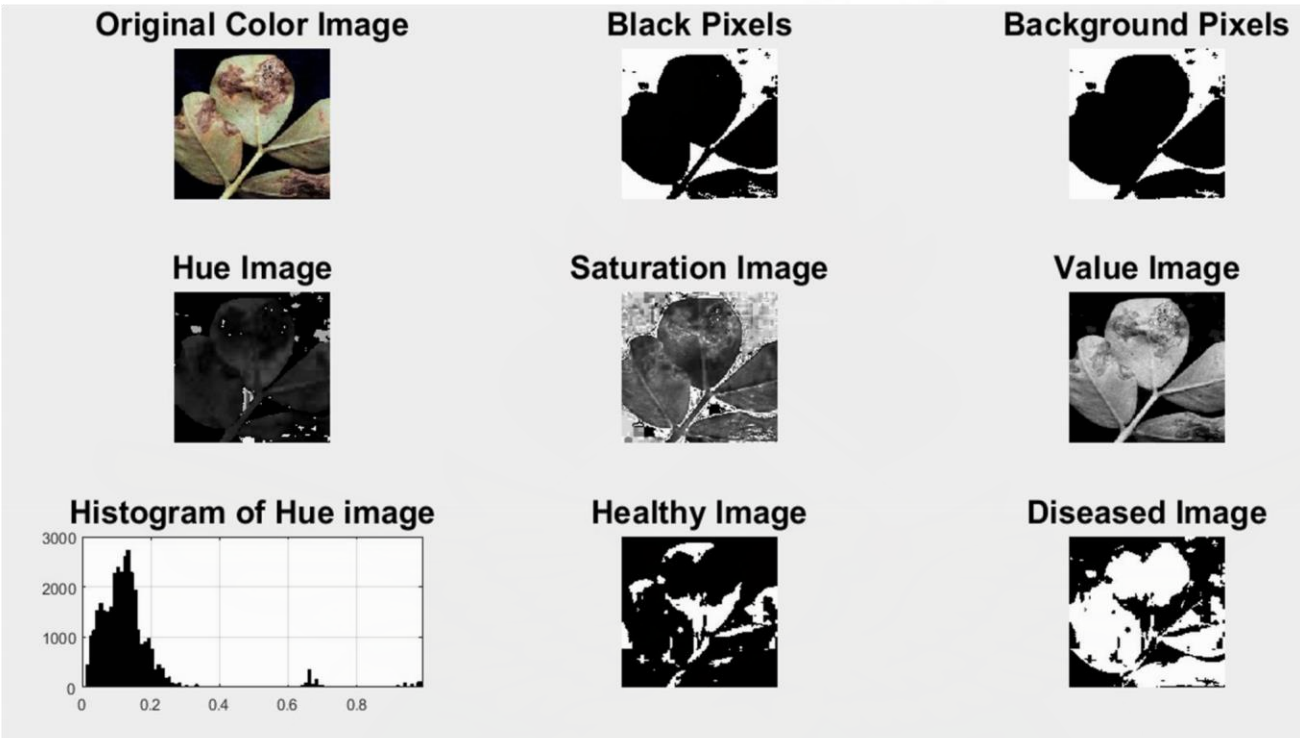


Figure 14 represents results obtained from image sample B after various forms of segmentation.

The area of fraction of disease was estimated to be **76.63 %** after thresholding. This was achieved by performing the various forms of segmentation and thresholding on the image. The same algorithm was used to determine the area of affected by the disease.

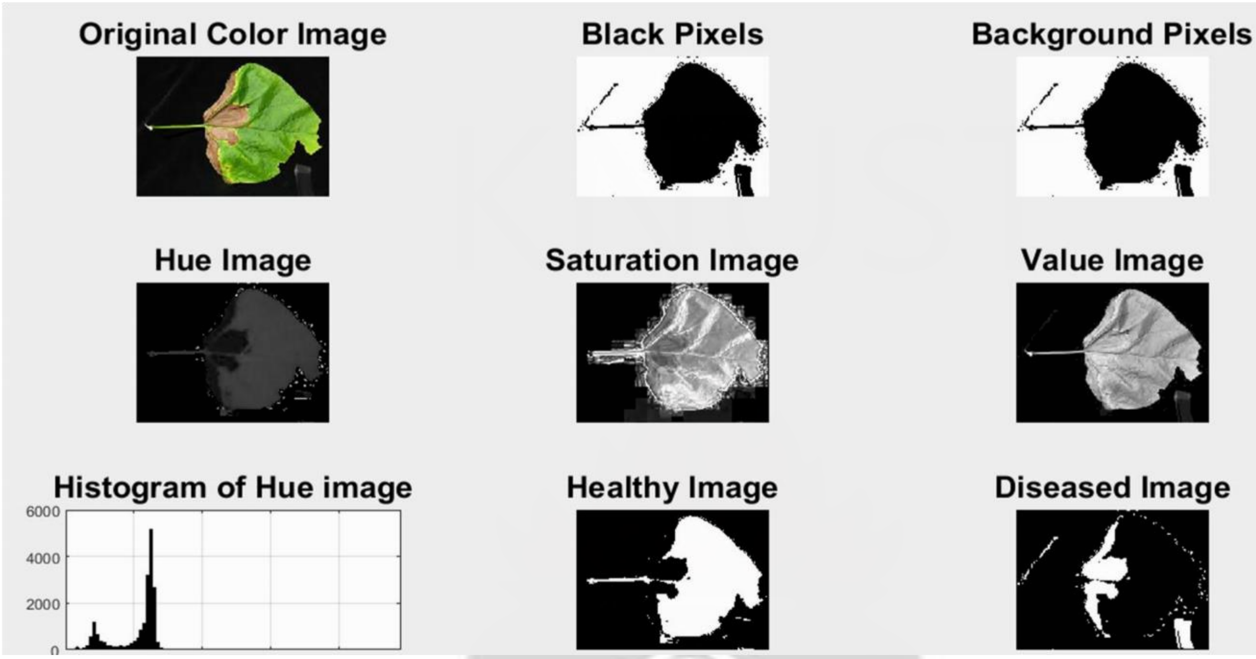


Figure 15, results obtained from image sample C

The area of fraction of disease was estimated to be **24.80 %** after various forms of segmentation and thresholding. This was achieved by performing the various forms of segmentation and thresholding on the image. The same algorithm was used to determine the area of affected by the disease.

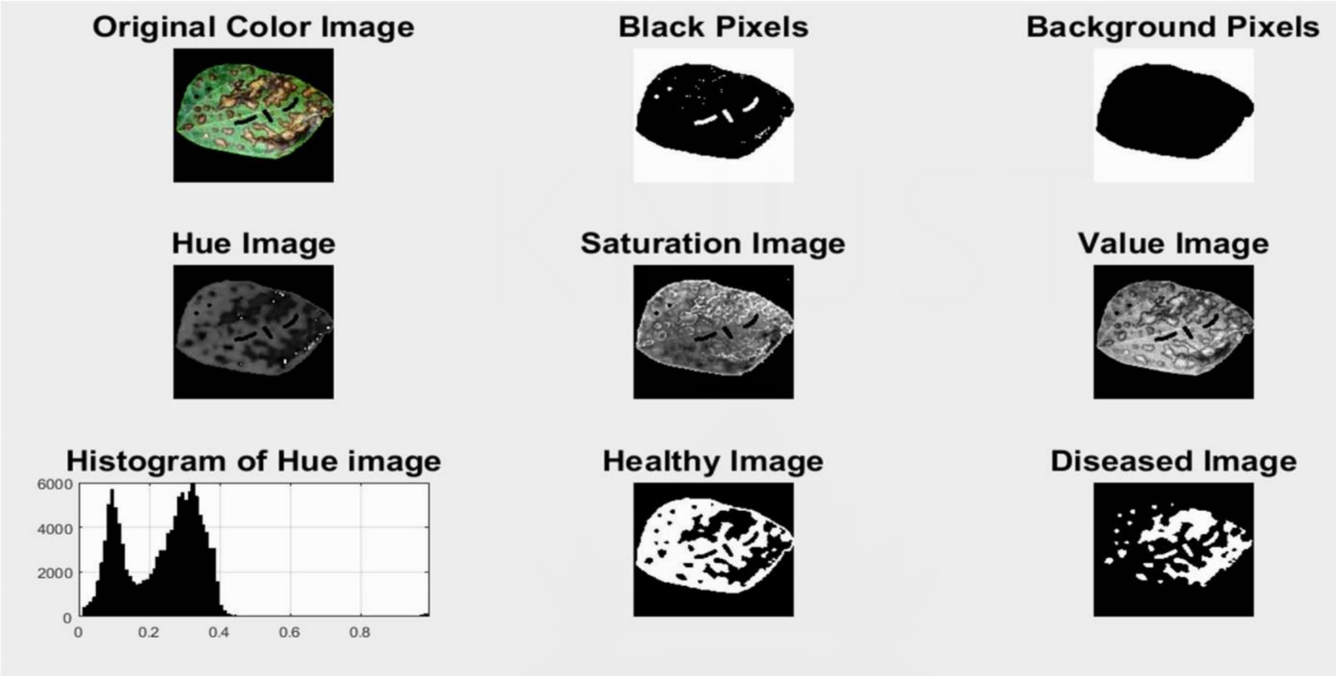


Figure 16, results obtained from image sample D.

The fraction of disease was estimated to be **32.27%**after various forms of segmentation and thresholding. This was achieved by performing the various forms of segmentation and thresholding on the image. The same algorithm was used to determine the area of affected by the disease.

Table 1: this table shows the summary of results obtained from the various experiments.

SAMPLES	% OF DISEASED AREA	% OF HALTHY AREA	TOTAL (%)
Sample A	20.10	79.90	100
Sample B	76.63	23.37	100
Sample C	24.80	75.20	100
Sample D	32.27	67.73	100

The table above represents the results in percentage from the various samples used in the project. The entire image was expressed in a percentage of 100 of which the diseased area is estimated from it.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

Introduction

The purpose of this study is to measure the severity of fungi caused diseases on leaves using the triangle and simple threshold methods. This chapter of the study deals with the conclusion and summary of the findings made by the writer.

The chapter continues to give suggestions and recommendations made by the author based on the findings of the study to assist other researchers who would like to conduct research on the same field of study. These recommendations would help future researchers to enhance and improve upon the research and even go into details of the study.

Summary

This study contains five main chapters with different subtopics. Chapter one of this study gives a brief introduction and background of the study. It further states the purpose of the study which is measuring the severity of fungi caused disease on leaf using triangular thresholding method. It further treats topics like significance of the study, research questions, objectives, limitations of the study and delimitations.

Chapter two also deals with the review of related literature. This is where works from other researchers are analyzed and revised by discussing the theoretical framework of the study as well as empirical evidences are of the study. Again, various concepts such as the origin and uses of image processing, image processing methods in relation to disease severity and effects of fungi caused diseases on plants were thoroughly analyzed. The chapter covered the examination of existing literature in relation to the study. Materials written by other persons or authors in context with the topic were considered. Major items considered in the chapter include **Image processing, Uses of image processing, Image processing methods and Image processing techniques:**

Chapter three of the study gives an account of the materials, principles and methodologies used to achieve the desired results of the study. These include algorithms, flowcharts and other materials to achieve the outcome of the research. It includes the procedure for acquiring the images, methods of segmenting and thresholding the image, and algorithm to measure the severity of the diseased area of the leaf through the image processing application.

Chapter four of the study dealt with the findings, analysis and interpretation of the data collected and the results obtained from the study.

This chapter gives interpretation of the main instruments used to conduct the study. The strategies were put in place with the aim that they will help measure the extent of damage caused by fungi on plant leaves. The results were arranged in simple forms using figures, diagrams, charts, percentages, etc, for easy reading and analysis.

The final chapter of the project summarizes the entire project by giving an account of the details of the research. It further provides an overview of the study by explaining the major topics of the study. Some of the areas considered in this chapter include summary, conclusion and recommendations.

Conclusion

This project was meant to measure the severity of fungi caused diseases on leaf. The study took into consideration the negative effects of leaf diseases on plants. Studies have proven that, the consequences of plant leaf diseases are great and difficult to deal with. However, leaf diseases, most especially those caused by fungi can be measured and estimated to ensure proper and adequate application of the correct concentration of fungicides to avoid agricultural loss and excessive use of chemicals on farm produce. Plant disease does not only reduce their products but also deteriorate of their variety and its withdrawal from cultivation. The use of pesticides and fungicides in excess for the treatment of such diseases increases the danger of toxic residue level on agricultural products and has been identified as a major contributor to ground water contamination. Again, farmers incur much loss due to cost of these pesticides as applied on plants. Therefore, there is the need to take greater caution and minimize their use in order to protect water bodies and human life. The algorithm used in this research proves to be one of the simplest ways of detecting and estimating leaf diseases in plants. It also proves to be one of the best in terms of accuracy because it works up to 97% accuracy in terms of results.

Recommendations

Agriculture as we know is the backbone of every economy no matter how well it is developed. Therefore, there is the need to pay much attention to it so that the right output will come from it. In our part of the globe where there is limited application of technology in agric, farmers find it very difficult to produce up to their maximum strength due to factors like rain and most especially plant diseases. It is therefore recommended that much attention will be given to the treatment of plant diseases to avoid much loss in agriculture. Also, governments should focus on training agric extension officers in order to be abreast with modern trends of agriculture paying much attention to ways of detecting plant diseases early enough to avoid it escalating. Again, farmers must also be given the needed attention and training as to how they should go about their farming practices most especially the use of pesticides and fungicides.

Also, right concentration of fungicides and pesticides must be applied to plants that are affected with various forms of diseases to avoid excessive toxic waste in food crops and contamination of ground water bodies.

Finally, future researchers should try to include into their work how best farmers can measure the right quantity and concentration of fungicides and pesticides based on the severity of plant disease before applying them on their crops to prevent ground water pollution due to excessive toxic waste and agricultural loss.

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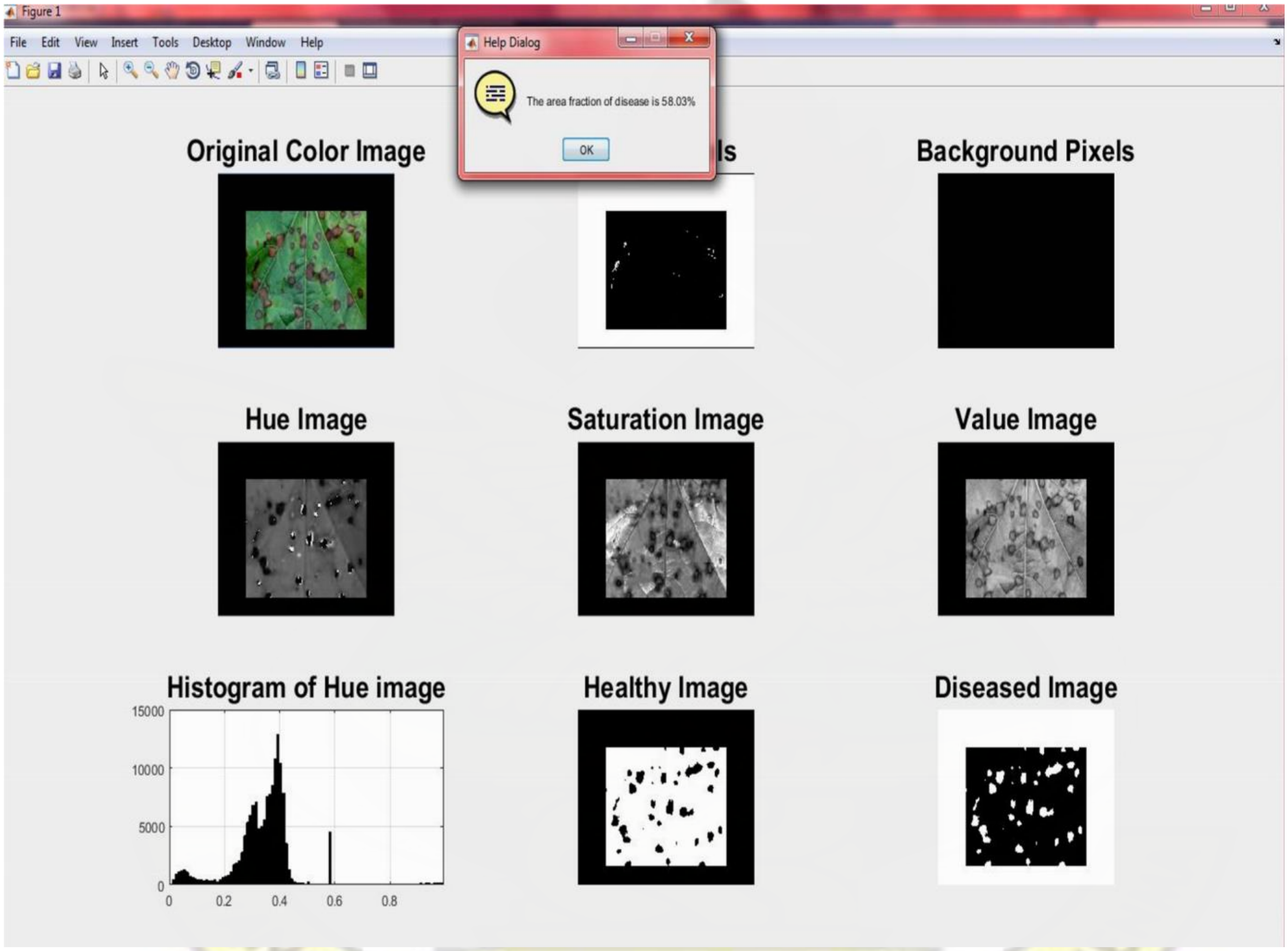
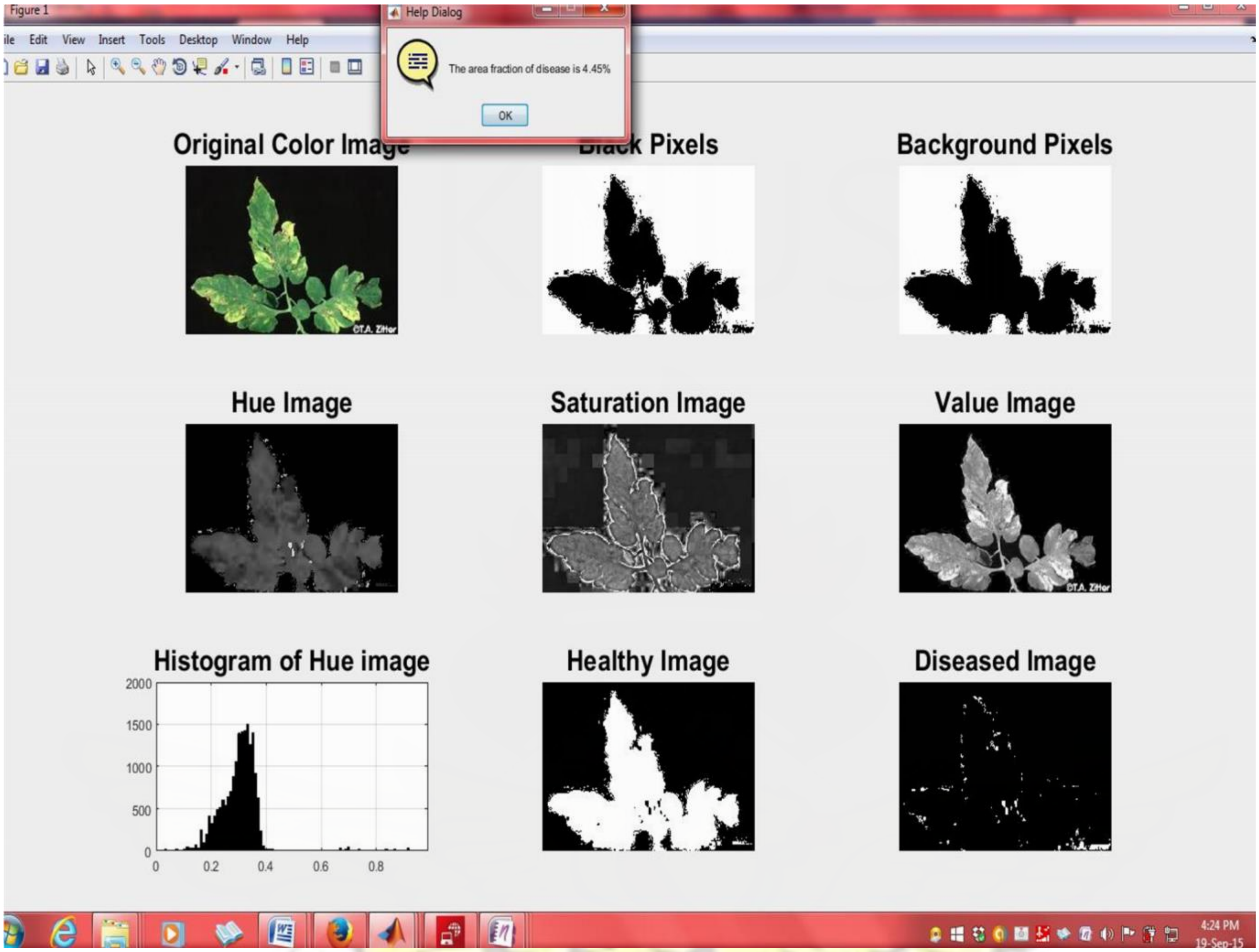
APPENDIX

Screenshot of other images tested

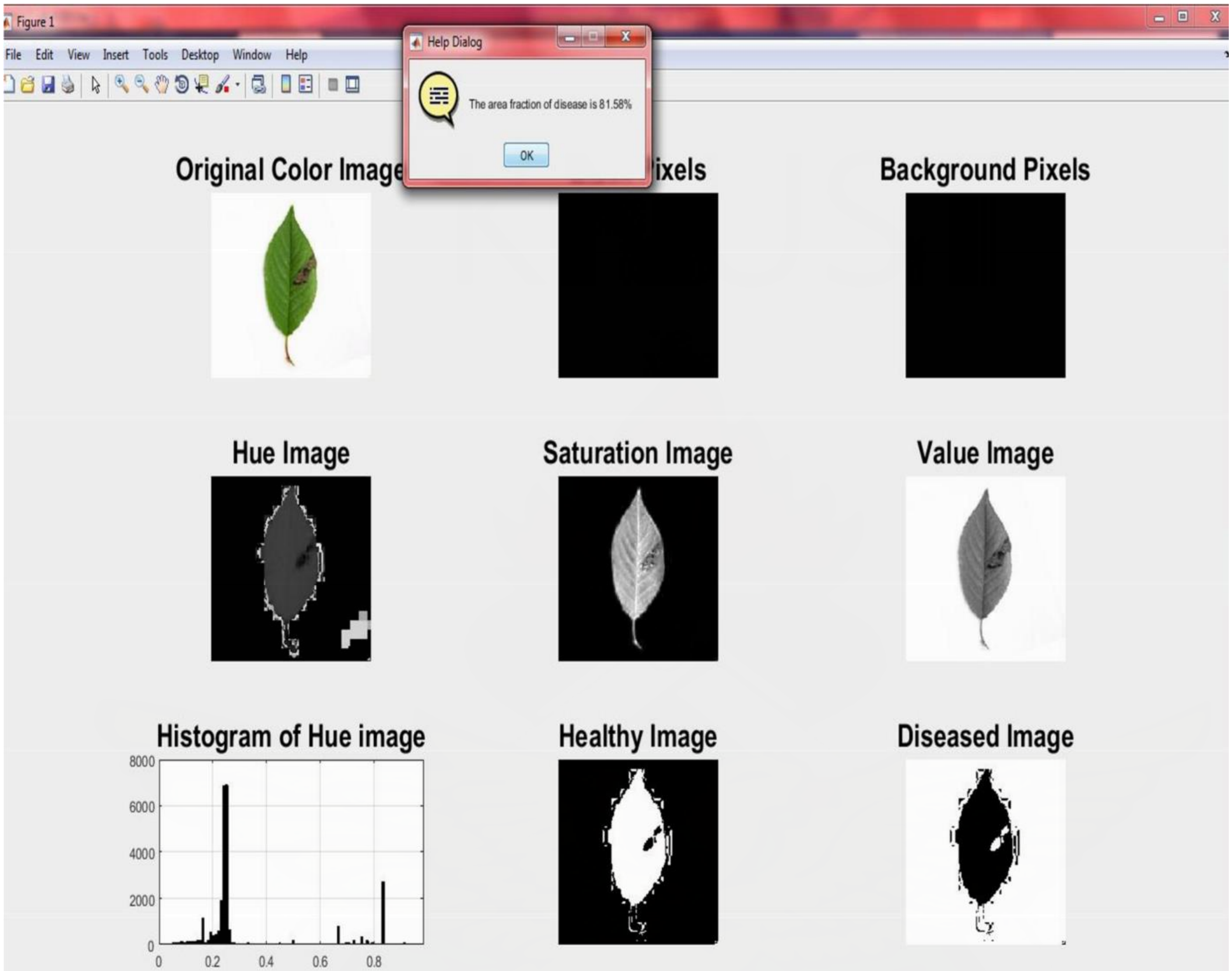
Below are other samples used in this paper to test the effectiveness of the algorithm. Each image was well segmented and the disease regions were estimated accurately with the same procedures used in chapter four.



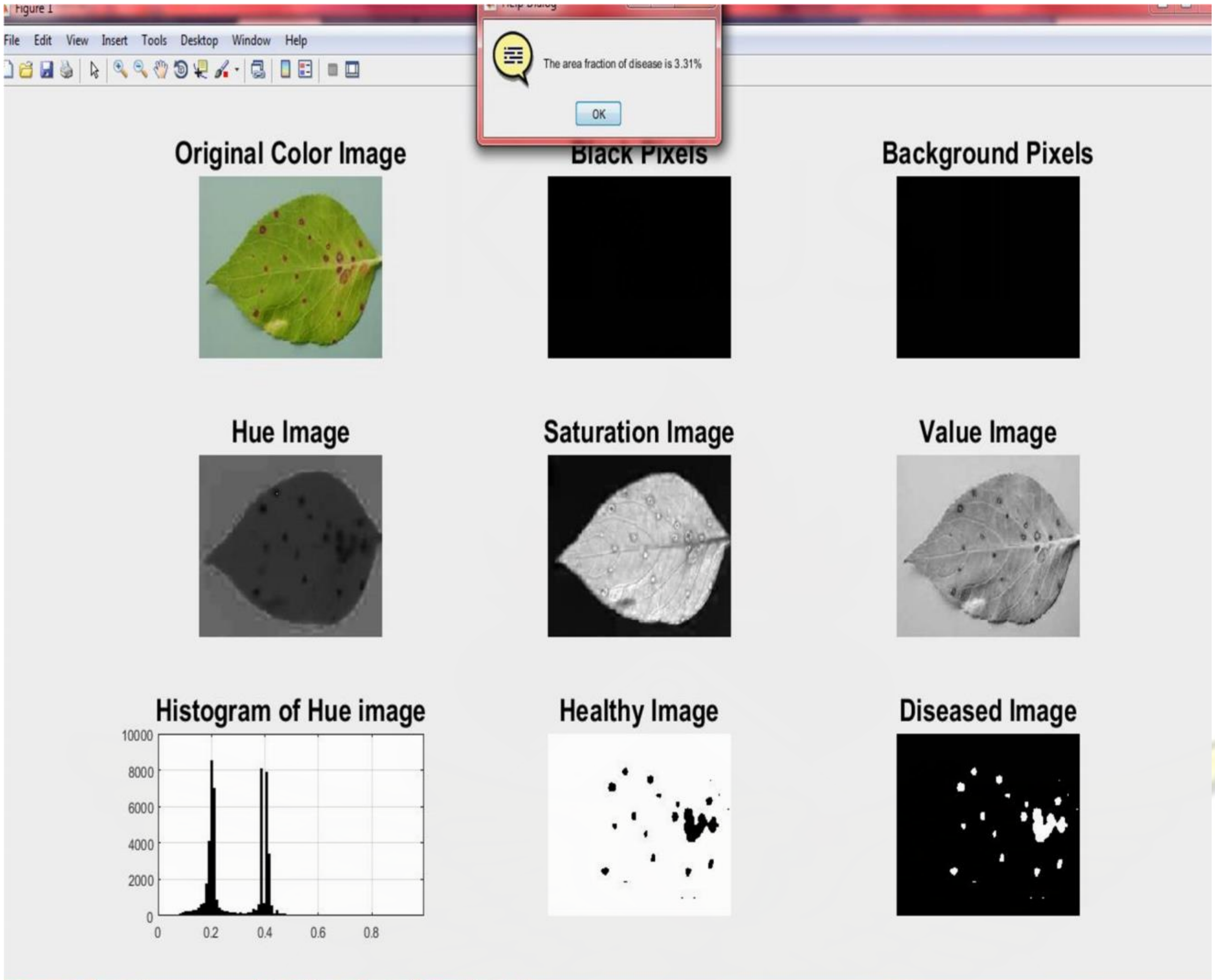
Affected region for this sample was estimated to be **54.03%**



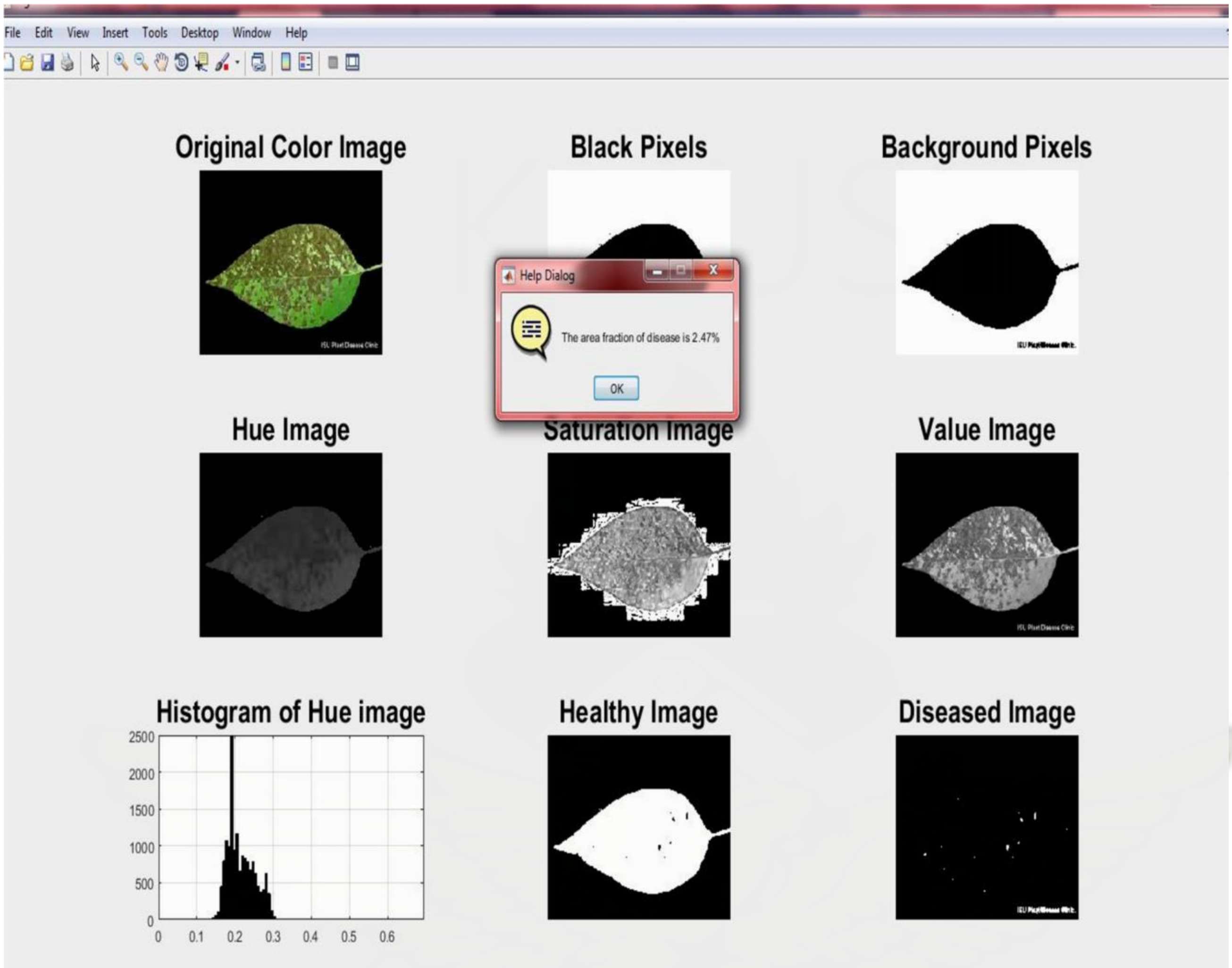
Affected region for the above sample was estimated to be **4.45%**



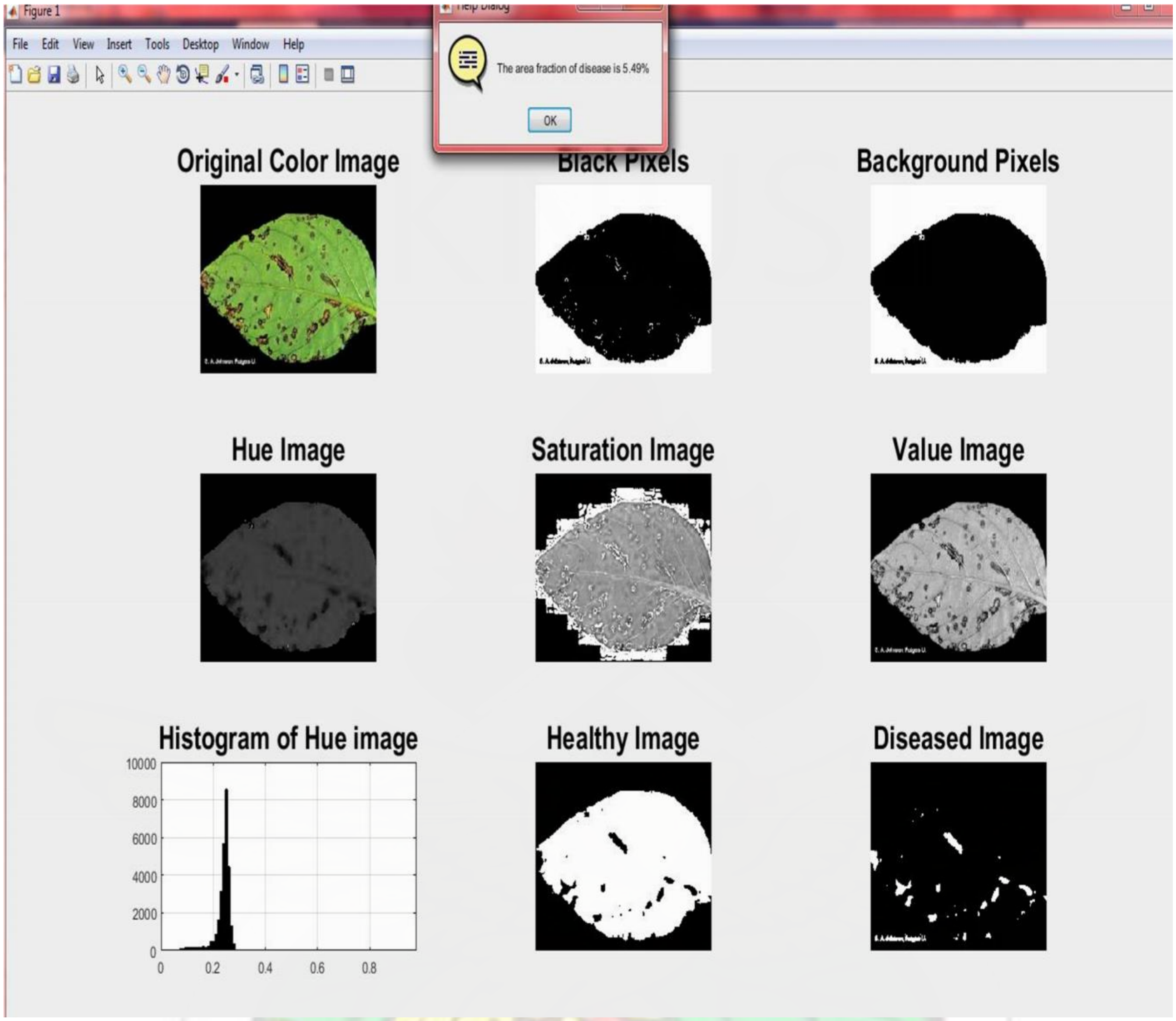
The diseased region for the sample above was estimated to be 8.15%



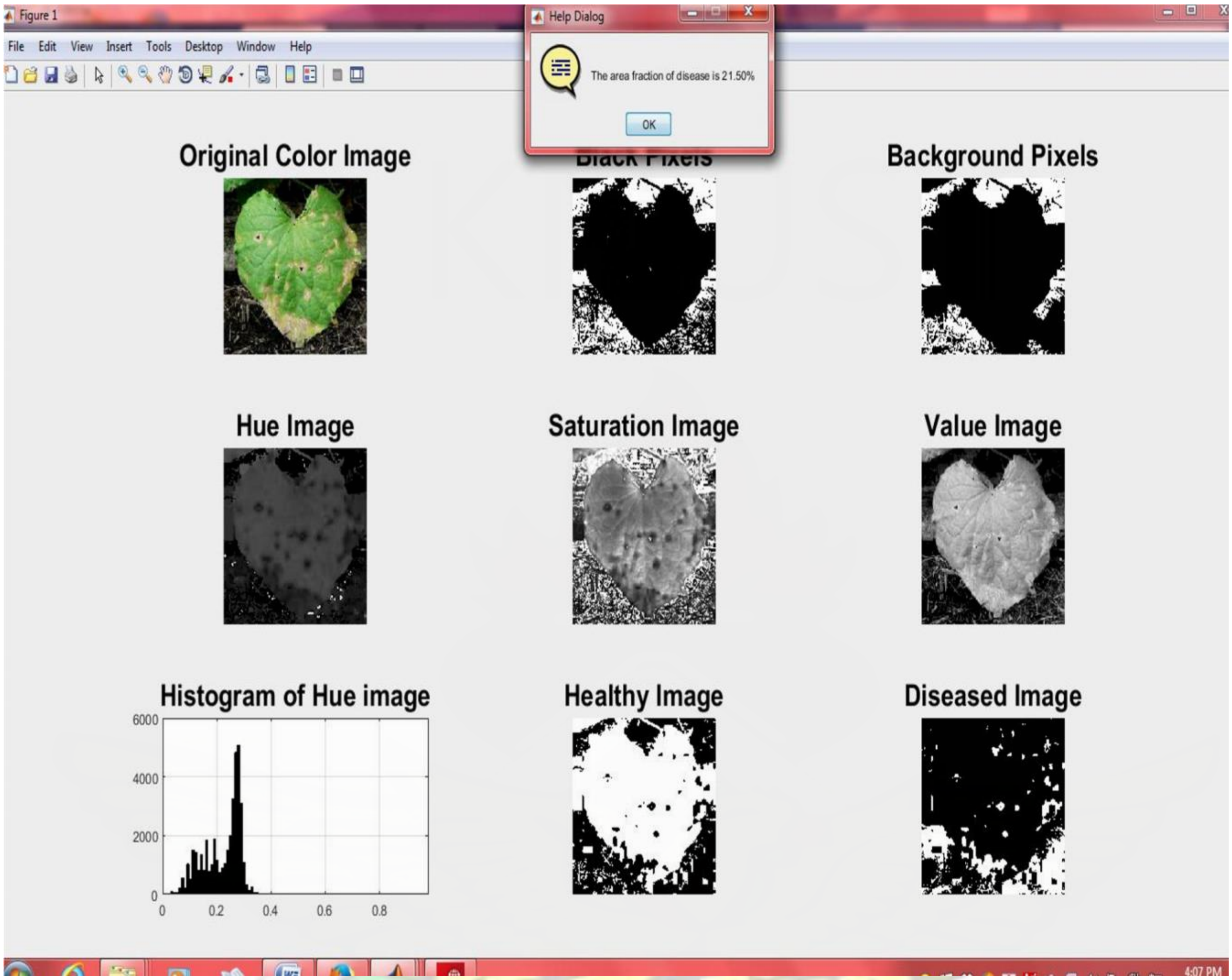
The diseased region for the above sample was estimated to be **3.31%**



The diseased region for the above sample was estimated to be **24.70%**



The affected area for the above image was estimated to be **15.40%**



The diseased region for the above sample was estimated to be **21.50%**