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Image processing system for identifying groundnut plant disease

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A B S T R A C T

Groundnuts (Arachis hypogaea), also known as peanuts are the edible seeds of a legume plant that grow to maturity in the ground. Diseases and its diagnosis methodology are the main challenges to groundnut production. Manual means of identifying plant disease is the most difficult activity with a high rate of mistake and time taking procedures. Therefore, the main aim of this research was to design an image processing system to identify groundnut plant disease. In general, the major significance of the study is to provide effective and simple groundnut plant disease diagnosis system that supports disease controlling mechanism and experts in the domain area. While the process of developing the system, researchers used purposive sampling techniques for acquiring 320 sample leaves images from four classes of groundnuts plant. Those are Cercospora personatum, Cercospora arachidicola, Puccinia arachidis, and healthy leaf from Bishan-Babile and Gemechu peasant associations in Babile district, and Awdal peasant association in Gursum districts in East Hararghe zone of Oromiya Regional State. Also, the researchers conducted a survey study which helps to identify experts view and deep understanding of the domain area. The design, phase used; adaptive median filtering, K-means clustering, SVM and ANN techniques with MATLAB programming tool. In general, the overall result shows that the developed system achieved a better result with an accuracy of 90.6%.

1. Introduction

Groundnut is the second most significant oilseed plant in the warm lowland zone of Ethiopia (Kebede et al., 2017). This plant is cultivated in a different part of the country from those regions East Hararghe zone of Oromiya Regional State produces a large amount of groundnut in the country (Kudama, 2013). However, groundnut production in Ethiopia is highly restricted by several biotic and abiotic factors. Disease is the major tackle in the production of groundnut by affecting both above and underground parts of the plant (Chala et al., 2014).(Solomon & Amare, 2015) also suggest that Cercospora leafspot of groundnut caused by Cercospora personatum (late leaf spot) and Cercospora arachidicola (early leaf spot) diseases are major problems in Eastern Hararege groundnut plant production. Although beside the disease, visual or manual identification of plant disease relates with inaccuracy, need of experts and time taking activities (Pendse et al., 2018), which might leads to less and low-quality production. One of the mechanism to combat this problems are helping farmers in diagnosing plant disease easily and an accurate disease identification to find the cure for the plant takes the major part (Astonkar & Shandilya, 2017).

Beside the fact adopting new technological aspects in the agriculture sector will improve the gaps shown in the field and image processing can be one of the technological tools used to provide a consistent, accurate, and reliable method to estimate disease. Image processing is a set of technologies, which is an image data analysis and processing algorithms and tools to improve the interpretation of different image information (Deserno, 2011). Image processing allows the extraction of useful parameters, and increases the likelihood of detection of small lesions more accurately (Gao, 2013). Image processing uses various techniques such as image acquisition, preprocessing, segmentation, feature extraction and classification to improve the quality of images and assists a lot in diagnosing plant disease to a great extent (Medjahed,

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2015). Therefore, in this study the researchers developed an image processing system that helps to diagnosis the specific diseases (Cercospora personatum, Cercospora arachidicola, and Puccinia arachidis) from the leaf part of the groundnut plant. While the development of the system necessary data is acquired from the leaf part of groundnut plant and domain experts. Although adaptive median filtering, K means clustering, SVM and ANN classifiers were used in the image processing system development. Finally, the major significance of the study is to provide effective and simple groundnut plant disease diagnosis system that supports disease controlling mechanism and experts in the domain area.

2. Literature Review

Groundnut, also commonly known as peanut (Arachis hypogaea), is a tropical legume mainly grown to produce oil and for human and animal consumption (Pratap & Kumar, 2014).it is a major source of digestible protein (25 to 35%), cooking oil (43 to 55%), and vitamins like thiamine, riboflavin, and niacin (Nautiyal, 2002; Savage, 1994). whereas disease and it is diagnosis procedures are the major problem in the production and quality of groundnut. To combat the plant from this disease a precise and on time disease diagnosing has greatest significance (Garcia & Barbedo, 2013). Therefore, image processing technique is one. of the useful tool in the detection process of plant disease through classifying and identifying (Astonkar & Shandilya, 2017). Image processing is a method of accomplishing actions on image to attain an improved image or to quantify visual parameters. Digital image processing is one of a method of image processing that follows the basic steps of image acquisition, pre-processing, segmentation, feature extraction and detection (classification) of the image (Tartu, 2013). In a recent study, it has been shown that image processing can be used to provide a consistent, accurate, and reliable method to estimate disease severity by using the plant root, flower, leaf, stems, and other parts.

Although several scholars studied plant leaf disease identification, weed detection, and fruit grading using image processing techniques. In this regard (M. K. Singh & Chetia, 2017) studied an automatic disease detection of plant leaf of Beans and Tea using image processing techniques. They also indicated using image processing helps farmers in identification of disease in the initial phase and provide significant information for its management. Similarity (Vibhute & K. Bodhe, 2012) also stated that the application of image processing can improve decision making for vegetation measurement. Study done on several diseases classification by using automatic detection and classification of plant leaf developed an algorithm and tested on jackfruit, mango, potato, sapota and other plants, which also produced an efficient result from the testing phase(V. Singh & Misra, 2017). Adoption of such technologies like image processing techniques in plant disease identification leads to fast and accurate result and also better productivity (Pendse et al., 2018).In general, most of the studies in image processing specifically in disease classification and identification states that using a digital image processing technique can support in effective disease identification and control, assisting experts and improved decision making.

3. Objectives of the System

3.1. General objectives

The main objective of the study is to develop image processing system for identifying groundnut plant disease to provide efficient disease controlling mechanism.

3.2. Specific objectives

- To acquire groundnut plant disease sample image for developing a prototype system
- To present feature extraction towards groundnut plant disease identification based on the leaf image
- To select suitable classification algorithm for groundnut plant disease diagnosis
- To develop a prototype system for identifying groundnut plant disease
- To evaluate the performance of the system and user acceptance level.

4. Proposed Model

The aim of the study to develop image processing system for identifying groundnut plant disease. Here the developed system intended for efficient disease controlling mechanism and expert support and modest detection method of a groundnut plants disease. To develop the system for identifying groundnut plant disease the researchers used the leaf part of the plant. The system started by acquiring image of a groundnut plant leaf with a good camera. After the acquisition of images, the acquired image should have to be pre-processed and segmented for removing unnecessary or disturbing factors in the finding of the disease from the given image. The next step is feature extraction. In this system, the researchers used morphological and textural features together as important and major characteristics of the image. This phase provides the basic appearance of the leaf related to the above basic features and leads to the classification step. The final step of the model is the classification or categorization as the system identifies the class of the groundnut, based on the data provided by feature extraction.

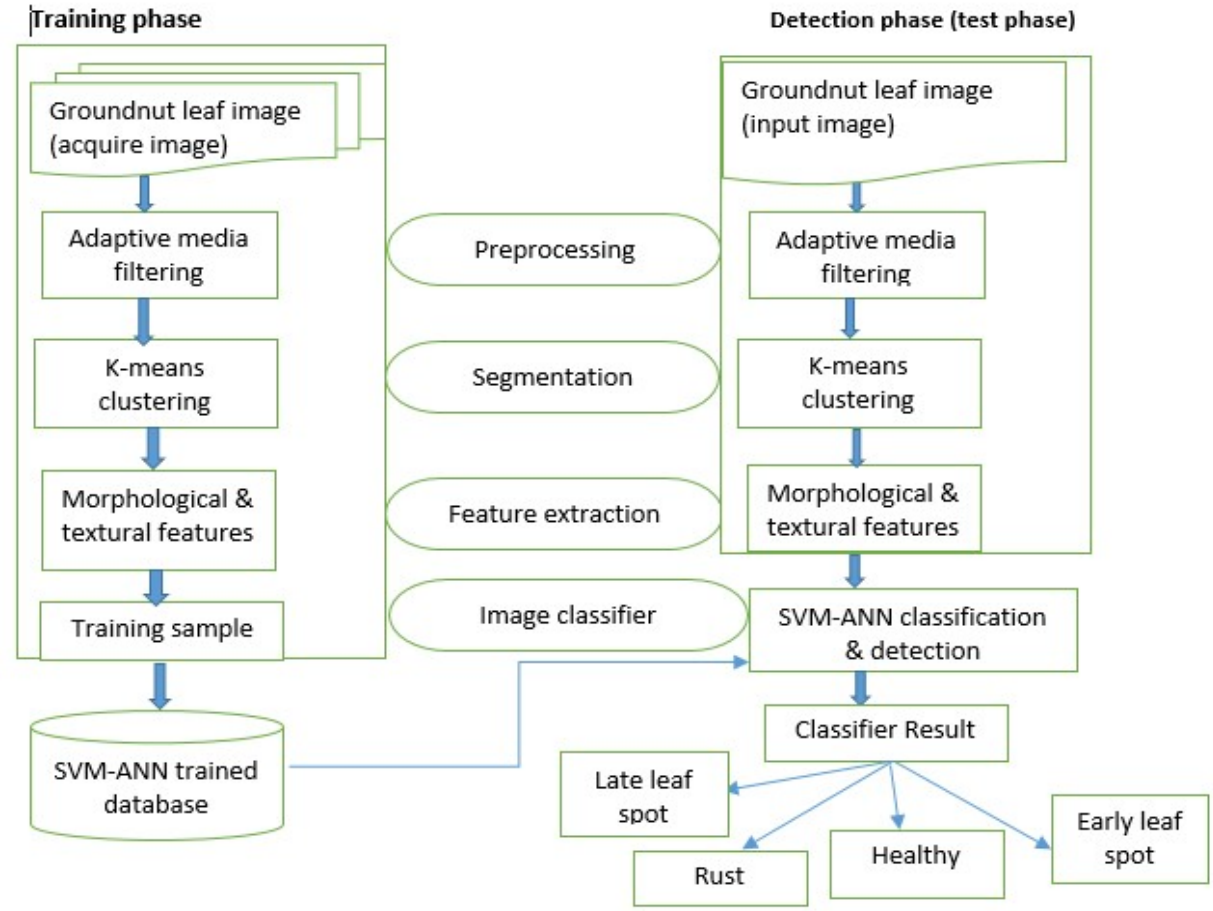

Figure 1. The architecture of the image processing system for identifying groundnut plant disease.

5. Methodology

5.1. Research framework

In the development of an image processing system for identifying groundnut plant disease the researchers used experimental research design method. According to Goodwin (2010), experimental research design is a systematic research study in which the researcher manipulated and controlled testing to understand causal process. It is important for an experimental research to establish cause and effect of phenomenon, which means, it should be that effects observed from an experiment are due to the cause. Experimental research can be either basic or applied in its goals, and it can be conducting a laboratory test or other fields. Experimental researches that take place in the field research outside of the laboratory, including both experimental and non-experimental methods. It is a way of gaining knowledge by means of direct and indirect

experience and evidence gathered data. In this study, experimental method was used for image processing techniques to designing a prototype system and testing. As a result, in this study the researcher used experimental method for model building, analysis, prototype development and performance testing, whereas non-experimental method was used for user acceptance testing and knowledge elicitation through discussion with experts and document review.

5.2. Image acquisition

The images of the groundnut leaves were acquired using two methods. The researchers acquired data by direct taking of the leaves images sample and also collecting a preserved dataset from Bishan-Babile and Gemechu peasant associations in Babile district and Awdal peasant association in Gursum districts in East Hararghe zone of Oromiya Regional State.

During the study a total of 320 leaf sample images were collected which are from three infected and one healthy leaf group of groundnuts. From various types of diseases that attack groundnut leaf Cercospora personatum (late leaf spot), Cercospora arachidicola (early leaf spot) and Puccinia arachidis (rust) are the major challenges in influencing production and quality (Park, 2006). Discussion also made with experts about the basic symptom, characteristics, and experimental analysis of the given disease classes.

Classes	Type of Disease	Kingdom	RGB image samples
A	Cercospora personatum (late leaf spot)	Fungi	80
B	Cercospora arachidicola (early leaf spot)	Fungi	80
C	Puccinia arachidis *(rust)*	Fungi	80
D	Healthy types of leaf		80
			320

Table 1. Total number of groundnut plant both infected and healthy leaf image

5.3. Image pre-processing

Image pre-processing is a removal of unnecessary blurred or noise, which includes dust, unwanted background and shot noises while the image acquisition step. In this study adaptive median filtering method was used to enhance the image quality and to reduce noise while detecting disease. Adaptive median filtering crosschecks pixels that are not similar to the majority of its neighbours and have a problem in the physical alignment with other pixels and it adjusts by replacing median pixel value of the pixels in the neighbourhood that has passed the noise labelling test. The major benefits are removing impulse noise, smoothing of other noise, and reduce distortion (Peng, 2004).

Standing from this notation
Zmin = minimum value in Sxy
Zmax = maximum value in Sxy
Zmed = median in Sxy
Zxy = coordinates (x, y)
Smax = maximum allowed size of Sxy

Algorithm
Level A: A1 = Zmed - Zmin
A2 = Zmed - Zmax
if A1 > 0 AND A2 < 0, go to level B
else increase the window size
if indow size < Smax, repeat level A
else output Zxy
Level B: B1 = Zxy - Zmin
B2 = Zxy - Zmax
if B1 > 0 AND B2 < 0, output Zxy
else output Zmed

Algorithm 1. Adaptive median filtering algorithm (Peng, 2004)


(a)

(b)

Figure 2. Pre-processed groundnut Leaf Image

These two images explain the original and pre-processed leaves of the groundnut plant to support the disease identification process in the system. The image in (a) indicates that the original groundnut leaf image infected by some disease which should have to be processed to exclude unnecessary blurred or noise. While the second image in (b) shows that the pre-processed image through an adaptive median filtering algorithm through a MATLAB software.

5.4. Image Segmentation

Image segmentation is the method of dividing the leaf image into different portions to provide significant information for examination. There are different kinds of segmentation technique but being wise in selecting the perfect method is a one of skill expected because of the segmentation algorithm must be suitable for the feature extraction algorithm. One of the basic clustering algorithms is K-means and this paper used K-means clustering algorithm in which "K" stands with the number of groups unified. The algorithm is based on dividing a kind of cluster algorithm and has advantages of briefness, efficiency, and celerity (Li & Wu, 2012). It aims to lower the measure between the centroid of the groups and, the given observation by iteratively including an observation to any group, so it ends when the lowest distance measure is achieved. Before the starting of dividing or segmenting the image, color mode exchange is done. From RGB (Red, Green, and Blue) color space to Lab (red, green, and yellow, blue) based on XYZ color space.

K-means Clustering Algorithm

1. Converting the image from RGB to L*a*b color space
    - L*a*b where L indicates a beam of light, A indicates position from red to green and B indicates a position between yellow and blue (Paper, 2017).
2. Using k-mean Clustering techniques for different (abnormal) colors
    - Deciding the number of K or groups. This study used three clusters.
    - Measure every pixel to its nearest centroid to decide in which cluster it's assigned. The Euclidean distance ED = $\sqrt{\sum_{i=1}^{N}(a_i\text{-}b_i)^2}$ is used while the study.
    - The clustering finished after every pixel is stable or clusters are unchanging.

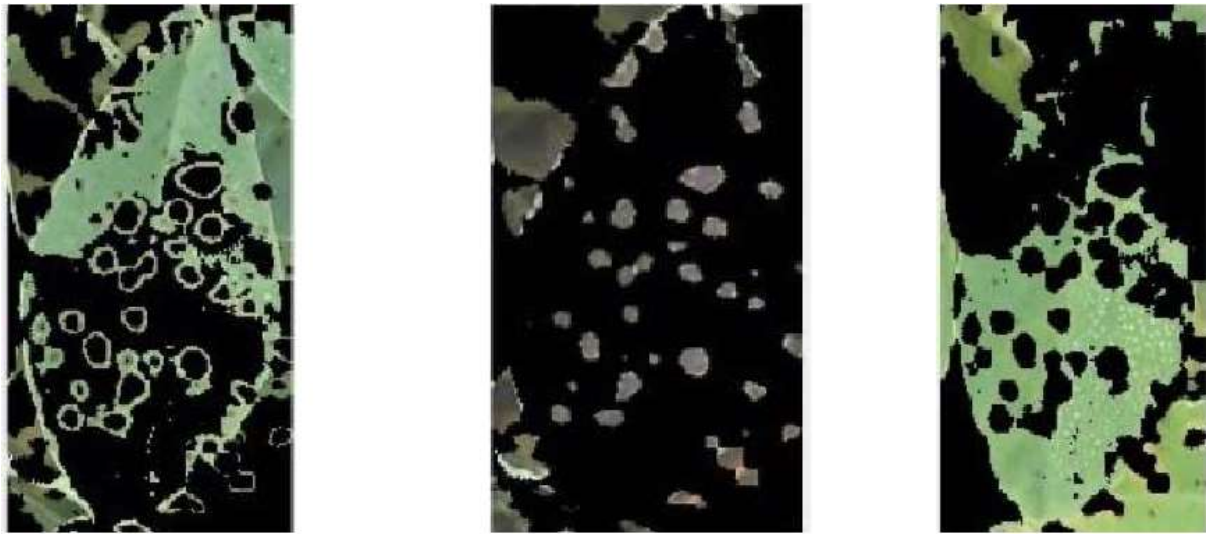

Figure 3. Segmented groundnut leaf image

The pre-processed image passed into the image segmentation process for clustering the images into three groups that indicates K means 3. All the images in the above figure 3 indicates the different portions of the segmented images to provide significant information for examination. Therefore, the system will select the image that provide a better information from the three grouped images in the segmentation process.

5.5. Feature Extraction

Feature extraction is one of the most significant steps to support the finding of the infected area on the image. Feature extraction is the process of transforming the input data into a set of features (Kotas et al., 2001). The extraction starts by signifying the given image features. Features may contain facts relative to color, shape, texture or context.

The quality of feature selection has a direct impact on the prediction process, so the study used the two most advised feature extraction methods which are textural and morphological features. As (Astonkar & Shandilya, 2017; Gupta, 2018) suggested that morphological and textural features are better in giving further results than other features with displaying how the color is distributed in the image. Five texture features are used to support the extraction process, which are correlation, homogeneity, contrast, entropy, and energy. In morphological features extraction, experiment seven geometric numerical descriptor features are calculated related to shape and size: Euler number, major-axis, extent perimeter, area, minor-axis, and compactness. Generally, the study used 12 sets of feature components in effectively extracting the given image to provide actual result for classification and detection phase

5.6. Detection and Classification

The final phase for the image processing process is detecting and classifying. The main aim of image classification is to categorize the findings of the given image into the classes. The study used SVM and ANN classifier algorithms and 12 labelled input features. The features help to decide whether the leaf is attacked by disease and also its disease class. Support Vector Machine (SVM) is a classifier method that performs classification tasks by constructing hyperplanes in a multidimensional space that separates cases of different class labels (Gove & Faytong, 2012). The SVM classifier categorizes based on the inputs provided by the feature extraction (textural, morphological). In this process, when the margin between the two groups is wide it's more effective. The other algorithm used in the classification phase is ANN (Artificial Neural Network). ANN is a type of artificial intelligence that imitates some functions of the person mind. ANN has a normal tendency for storing experiential knowledge (Kamavisdar et al.,

2013). Which is one of the best classifiers to learn from the surrounding and handling a large amount of data. In this study, feed-forward multi-layer perceptron architecture was used with back propagation learning algorithm to minimize the loss function in the whole network structure and the output layer.

Result and Discussion

The study developed a prototype system for identifying groundnut plant disease. The experimental results were used ANN and SVM classifier using holdout validation at 30%. The total number of dataset was 320 groundnut leaf images. In the classification and detection process the system results of four classes; Cercospora personatum (late leaf spot), Cercospora arachidicola (early leaf spot), Puccinia arachidis (rust), and healthy leaf. From the total dataset of each groundnut leaf image type, 70% was used for training and to build classification model, and the remaining 30% of the total was used for testing data. From the total of 320 dataset, 224 were used for training and 96 testing were used for accuracy, sensitivity and specificity measures. This results were proccessed by Confusion matrix using four categories: True Positive (TB), False Positive (PF), False Negative (FN) and True Negative. True positive is infected and healthy images that were identified by the domain expert as correctly identified and also classify results identify by the prototype system as correctly. False positive occurs when incorrectly image data inputted into the system and the system is give result as classify result correctly. That means some incorrect images may be retrieved by the system as relevant. True negative is incorrectly images identify incorrectly by the prototype system and expert domain. This is the image when incorrectly detected were inputted and the proposed system classify negative decision. False negative is the images when incorrectly identify images were inserted in the system for testing and the prototype system classify positive result.

Therefore, the researchers it can get the following results which help us to perform the groundnut leaf image detection has been determine through accuracy, sensitivity, specificity and F-measure. True positives (TP) = 57, True negatives (TN) = 30, False positives (FP) = 5 and False negatives (FN) = 3. From the performance results was used by ANN algorithms, the overall detection accuracy was 90.6%, while sensitivity was 91%, specificity was 90% and F-measure was 93%. The other algorithms (SVM) overall detection accuracy was 74.6 %, while sensitivity was 75 %, and F-measure was 76%. Therefore, SVM classifier recorded less accuracy than the ANN classifier.

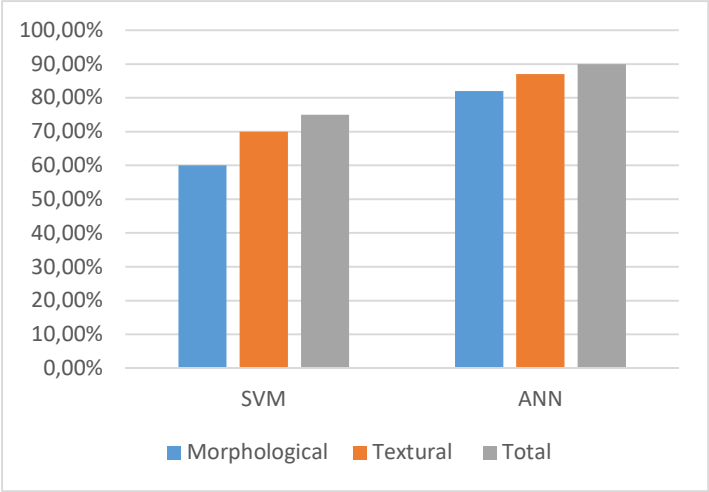

Figure 4. Summary of all classification model accuracy performance

Generally, in this study, the results show that using ANN classifier is more reliable method than the SVM classifier based on the computed feature extractions. The developed automatic system shows good accuracy and efficiency, thus can be used to assist agriculture experts in making decisions.

To show the experimental results, the researchers took a sample image from Cercospora arachidicola (early leaf spot) and inserted to the groundnut plant disease detecting system. Here the figure shows how the image is pre-processed, segmented, feature extracted and the classification results

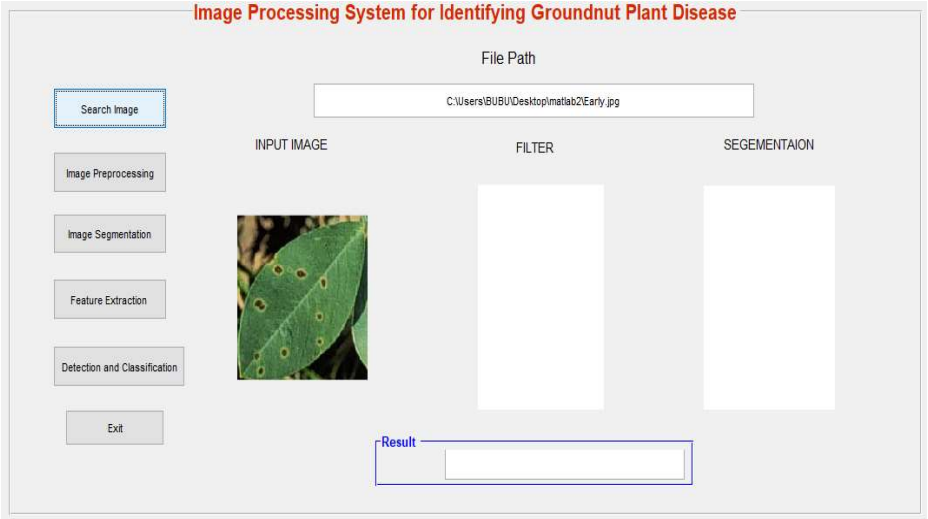

Figure 5. Sample graphical user interface to load groundnut leaf image

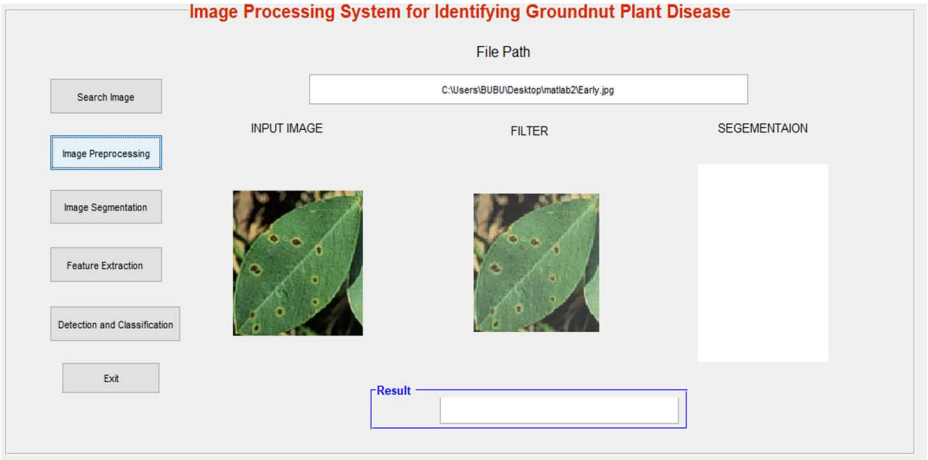

Figure 6. Sample graphical user interface for filter

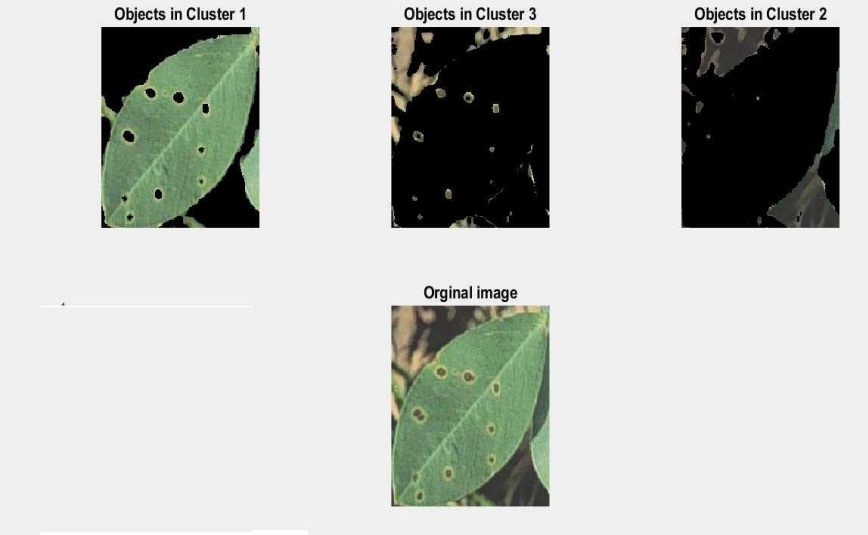

Figure 7. Sample graphical user interface for segmentation image using K-Means clustering

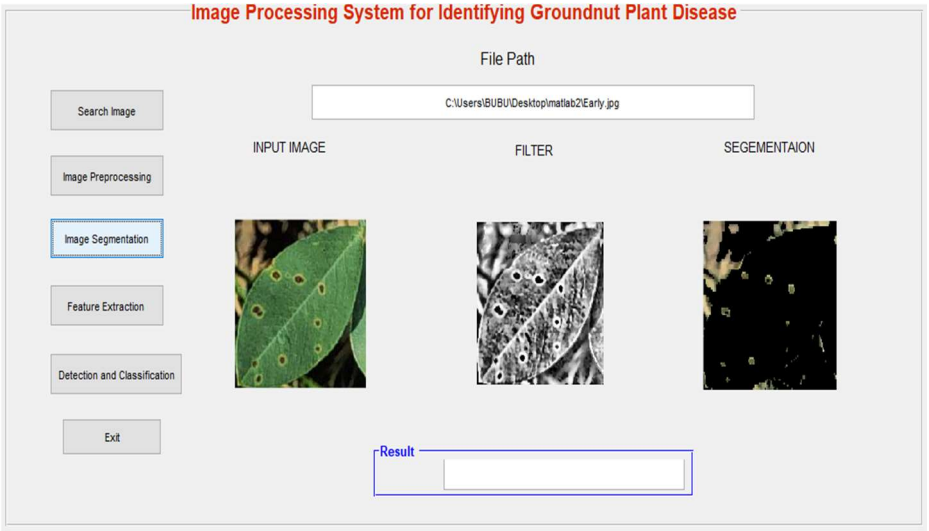

Figure 8. Sample graphical user interface for selected image segment using K-Mean clustering

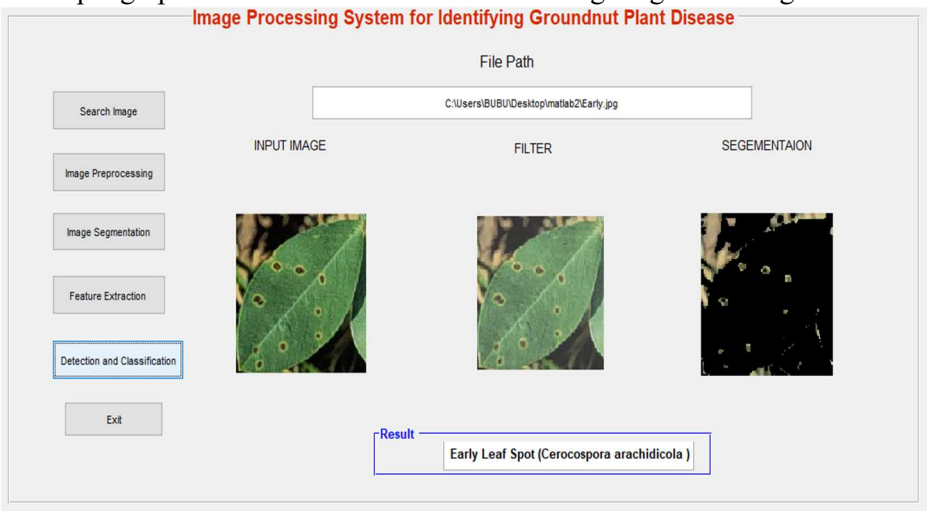

Figure 9. Sample graphical user interface for detection and classification mode

Finally the above figures tried to show the overall graphical user interface for the system. Which starts from figure (5) by loading a groundnut leaf image in to the system and it proceeded by filtering or image pre-processing techniques in figure (6). Figure (7 and 8) showed the image segmentation step by clustering the pre-processed image into three groups and selecting the better image from the cluster for providing significant information for feature extraction. Finally figure (9) states the feature extraction from the information accepted in the above steps and classification or detection of disease with an end result of early leaf spot Cercopora arachidicola.

Conclusion

In this paper, the researcher developed an image processing system for identifying groundnut plant disease to provide efficient disease controlling mechanisms, expert support systems and modest detection methods. During the development the researchers acquired the necessary information from the domain experts. The total sample of dataset 320 of leaf images were collected from Babile district peasant associations, and Gursum districts peasant associations in East Hararghe zone of Oromiya Regional State. The collected dataset was used for data training and evaluation using holdout validation at 30%.

In this study four class of groundnut leaf (cerocospora Cerocospora personatum, cerocospora Cerocospora arachidicola, Puccinia arachidis, and healthy leaf.) were used due to their disease severity in the region. Although in this study researchers used adaptive median filtering and K-means clustering for image preprocessing and segmentation phases. Morphological and textural features used 12 sets of

feature components in effectively extracting the given image to provide actual result for the classification and detection phase. The accuracy, sensitivity, specificity and F-measures improved the performance of the prototype results of ANN were 90.6%, 91%, 90% and 93% respectively, whereas SVM were 74.6%, 75%, 75% and 76%.The accuracy, sensitivity, specificity and F-measures improved the performance of the prototype results of SVM were ANN reached an average result of 90.6 accuracy level and SVM scored 74.6 correct classification.
Therefore, the experimental results indicate that the ANN classifier is the best algorithm in comparison with the SVM classifier based on the computed feature extractions. Finally, a graphical user interface (GUI) has been developed to read the image and display the result based on the groundnut leaf classes.

Recommendation

This study mainly focused on the disease that infects the leaf parts. Some diseases attack the groundnut plant on the stem, root, flower or whole body of the plant. So, the researcher can further investigate the disease appearing on the stem, flower and root.

Although the system performs detecting the diseases for the specified classes, once the identifying has been done appropriate treatment for the diseases are outside of the scope of this research so researchers recommends future work should consider further development in its treatments.

Finally, the paper, designed and developed a system used for identifying the groundnut plant disease beside this the system does not evaluate the severity of the disease. So, estimating the severity of the disease can be a future work.

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