PLANT LEAF DISEASE CLASSIFICATION AND DETECTION SYSTEM USING MACHINE LEARNING

G. Geetha1*, S. Samundeswari2, G. Saranya3, K. Meenakshi4 and M. Nithya5

1 Department of Information Technology, School of Computing, SRM Institute of Science and Technology, Kattankulathur, Tamil Nadu, India 603203.
2 Department of Computer Science and Engineering, Sri Sairam Engineering College, Tamil Nadu.
3 Department of Information Technology, School of Computing, SRM Institute of Science and Technology, Kattankulathur, Tamil Nadu, India 603203.
4 Department of Information Technology, School of Computing, SRM Institute of Science and Technology, Kattankulathur, Tamil Nadu, India 603203.
5 Department of Computer Science and Engineering, Sri Sairam Engineering College, Tamil Nadu.

*Corresponding author e-mail: geethag@srmist.edu.in

Abstract. In a developing country like India agriculture plays a noteworthy role. Agricultural intervention in the livelihood of rural India indulges by about 58%. Among the agricultural products, tomato is one of the most used crops. Thus, preventing significant loss in quantity and yield of tomato is majorly dependent on recognition and classification of diseases a tomato plant might possess. Latest and fostering technologies like Image processing is used to rectify such issues using different types of techniques and algorithms. Initially, the leaves of a tomato plant get affected, when plant develops a particular type of disease. In this project, four consecutive stages are used to discover the type of disease. The four stages include pre-processing, leaf segmentation, feature extraction and classification. To remove the noise we are doing the pre-processing and to part the affected or damages area of the leaf, image segmentation is used. The k-nearest neighbors (KNN) algorithm, which is a guided, supervised and advanced machine learning algorithm, is implemented to find solutions for both the problems related to classification and regression. During the terminal stage, user is recommended with the treatment. Mostly live plants are adversely affected by the diseases. This paper imparts representation of leaf disease detection employing image processing that can identify drawbacks in tomato plant from images, based on color, bound and texture to give the brisk and reliable results to the farmer.

Keywords: Image processing, k-nearest neighbour, feature extraction.

1. INTRODUCTION

In countries like India it is of utmost importance to bring technological advancement in the fields related to crop productivity. Research initiatives and tentative study process in the important domain
of qualitative farming is focused towards improving the yield and food crop standard at low cost, with greater monetary outcome. Agricultural building model stands as a result of a compound interlinking of soil with seeds, and chemicals used to enhance growth. Vegetable and fruits exists as one of the present significant agricultural achieved output. In directive for getting surplus and effective worthy products, a product value examination and improvement has always been importantly imperative. Diseases are disablement to the conventional state of the plant that translates or hinders its important roles such as transpiration, photosynthesis, fertilization, pollination, germination etc. They distorting diseases are spawned by pathogens like, fungi, bacteria and viruses, because of unfavorable environmental situations. Accordingly, the preliminary stage for diagnosing of plant disease is a significant task. Farmers need periodic monitoring by professionals which might be prohibitively costly and time absorbing. Thence, looking for quick, less costly and precise ways to smartly detect the diseases from the indicators that look to be on the plant leaf is of great pragmatic importance. In our study we are proposing a system which can be used to identify the particular type of disease a tomato leaf might have. It is of major concern to identify the type of disease an important crop like tomato can have, by implementing upbringing technologies like image recognition, which represent the application function visually and it is also an important reason for making digital technologies popular.

Many people and technological groups are involved in the field of agriculture to increase the yield and throughput. There has been various techniques used in the past to solve problems related to disease spread in a tomato plant. With the advancement in technology tomato plant disease detection have become more easy and precise. In our system a different approach, i.e. KNN algorithm is used for the same. Various kind of methods have been used recently to determine the type of plant disease [1]. Some of these involves analysis and study of chemical analysis method to determine plant diseases [2][3], and ways which are indirect by implementing physical techniques, like spectroscopy of the leaf and imaging [4][5], to get information related to properties of tomato plant. Following this, the merits of the project contrasted with the existing technologies are related to the underlying points:

- The system avoids the process involved in gathering inputs for studying them in the laboratory, because of pre-existing images taken in place of the plant diseases. It examines the chances where a particular plant is concurrently simulated with higher than one pest or disease in the unchanged recorded input. The outlook deploy inputting of various images apprehended by various cameras with diverse resolutions, like mobile phone and the other available cameras devices. The project is systematically pact with different conditions related to illuminations, the size of actors in an image, and surrounding distinction, etc., holding across the neighboring part of that particular plant. It imparts a feasible functioning approach that is able to maneuver in the domain by not using costly and complex and compound technologies.

2. LITERATURE REVIEW

Machine learning in detecting and classifying diseases of a plant leaf

Identification of diseases is one of major area in agriculture which needs to be taken care of, though many practices have been done and implemented to cope up with this issue, rapid and quick identification of the diseases still remains in state of inchoate. The use machine learning in facilitating the identification and detection helps to counter this problem to a much greater extent.

Reviewing classification and detection on plants using ML.

The paper gives an elaborate view about the techniques which can be implemented for detecting and classifying the various plant leaf diseases caused by bacteria, viruses and fungi. Based on their morphology i.e., their particular form, shape, or structure the diseases detected through classification are categorized. The techniques used in classification aids in automatic detection of the diseases of plant leaf [10].

Machine learning in detection of stem diseases of jute plant.

In this paper detection of diseases of the stem plant is done, using the HSV algorithm, GLCM algorithm and SVM to perform and initiate the segmentation process, followed with feature extraction
and classification respectively. It discusses the removal of noise, conversion from RGB to HSV and vice versa [19].

**Detection of abnormalities of the leaves of plants and training using papaya leaves.**
This paper talks about the detection and recognition of abnormalities of plants for training and study papaya leaves were taken. Random forest classifier was used for classification and it got trained using images of leaves with an almost seventy percent accuracy [20].

**Apple leaf disease detection.**
The common Apple leaf diseases like rust, grey spot, brown spot were discussed and found out with the help of deep learning algorithms and improved CNNs. The dataset for diseased leaves were generated, processed and collected. New deep CNN model designed to identify small diseased spots [21].

**Improvisation in our work:**
We understood the functioning of the classification algorithms, feature extraction algorithms, segmentations algorithms etc. We studied how detection of the disease is done automatically and the same is implemented effectively in the real time project. We chose tomato plant leaves for study, training, testing and detection of diseases.

**Study of plant leaf diseases and use of digital image processing**
The digital image processing provides a vast area for identification of diseases through the various algorithms it supports.

**Image processing techniques in identifying fungal crop diseases.**
The most common bacterial, fungal and viral diseases are studied which affects the plant leaves and roots on wide scale and reduces the productivity of the plants can be easily studied and identified through RGB to grey scale conversions [11].

**UAV for pests and weed using open computer vision**
In this paper drone cameras systems are used for detection of pests or diseased weed or crops. When the diseased areas are identified, those particular areas only are treated with fertilizers or pesticides and not the whole region so that the control can be done swiftly and in the minimum time possible [12].

**Severity measurement using image processing.**
Simple threshold methods and triangle threshold methods are used so that the lesion area and are of the leaf can be segmented. Categorization is done calculating quotient of lesion and leaf regions. Plants such as sugarcane have various kinds of such diseases which can affect the amount and the quality of crop and its yield. To avoid this it’s important to know the severity of the diseases so the appropriate amount of fertilizers can be used in time.

**Improvisation in our work:**
Understanding the pain and efforts of the farmers and how much time is devoted to cultivate a crop for one season, we employed the method which monitors the plants and its leaves from very beginning i.e., by using digital image processing. Early detection can save the farmers from huge losses hence our work focuses on early and correct detection of diseases using digital image processing so that neither the crop nor its yield is affected. Also the algorithms which are supported by image processing are quite useful in segmentation and in feature extractions which forms an essential part of the project.

**Selection of algorithms**
In machine learning various algorithms are available for feature extraction, clustering, segmentation. Selecting the most suitable as per needs of the task can be tough at times. To reduce the complexity and improve the time of response selection of the most suitable algorithm is required. We did a comparative study of the algorithms used in various previous projects and reasoned out the best one suitable for the project.

**Pre-processing and filters.**
Before we start working on the image we need to smooth out the image and resize it for further working. Various kinds of noises are also available in the images like Gaussian noise, shot noise, noise related to salt and pepper representation, Quantization Noise (Uniform Noise), film noise etc. [22]
There are different methods for removing different kinds of noise in our case we have salt and pepper noise hence to remove such kind of noise median filter is considered to be one the best algorithms, so we went ahead with the same.

**Segmentation**

The functioning and well known and significant are of image processing has to be segmentation as it derives useful and more appropriate to say meaningful data set from, from meaningless data by segmenting the parts of the image into several parts. It can be classified on the basis of region, edge threshold, feature and model. Out the above ours project deals with feature extraction so segmentation on such basis is important to simplify the further work and, we found that K-Mean algorithm which works well for feature extraction segmentation also is the one of the mostly widely used and easy to implement algorithm. Hence we decided to go with it.

**Feature extraction**

The basic geometric features which are extracted in feature extraction are diameter, physiological width, leaf area, leaf perimeter, morphological features, rectangularity etc. The GLCM or the Grey level Co-occurrence Matrix a traditional algorithm is very often used to extract the spatial dependency of the texture. Similarly another algorithm used for feature extraction is HOG i.e. Histograms of Oriented Gradients in the word we proposed we have used this system because this promises performance. Also, another advantage of HOG is that the very general structure of the object is captured by this algorithm. Hence we chose to work with GLCM and HOG.

**Classification**

The algorithms used for classification are quite commonly used for almost all similar projects like SVM i.e., Support Vector Machine, CNN, KNN. The classification is a necessary step as it compares the values received after the feature extraction step is compared with a pre-calculated set of data here we went ahead with KNN algorithm though both are supervised algorithms the KNN is simple easy and flexible to implement. It is also quite robust to data containing noise.

**Improvisation in our work:**

Different plants require different algorithm depending upon various factors some even upon the morphology [10]. We compared and contrasted each of the above algorithms before finally selecting it with test and trial methods.

**Why tomato!**

Tomatoes are one of the most popularly known vegetable throughout the globe which finds its application in numerous areas namely curries soups salads etc. The tomato production has also seen a considerable boost in the recent two decades. The Asians countries have now overtaken the production of highest number of tomatoes which earlier was in the hands of European and American countries [14]. The crop still faces destructions and setbacks in full potential production due to lack of automation and well implementation of the technology.

**Current trends and future**

Tomato plant being the second produced and grown vegetable in the world. Also it is affected by over 200 plus diseases. In future the demand of the vegetable is going to only boost with increase in human population.

**Disease detection in tomato plants**

The detection of diseases in tomato plants is quite easy comparatively to other plants such as sugarcane, jute, papaya, cucumber, paddy etc. Various new methods have been employed with the advances in technology for finding out the diseases in tomatoes but most of them lack in quick and early detection of diseases which eventually affect the crop yield.

**Advances in Research of plant Pathology**

We know that plant have inherent ways to resist diseases but the pathogens find some way or the other to develop resistance against them. The latest developments and research such as Nano–sequencing technique have helped to boost the yield and production of the tomatoes.

**Improvisation in our work:**

- Considering the demand and its production we decided to go with the tomato plant.
Other algorithms and techniques used – Study for compare and contrast
Various works have been done in this field using not just the algorithms we used but also using other techniques and algorithms.

**Genetic algorithm methods**
The Genetic algorithm methods make use of the characteristic features on the chromosomes of the original set of features. Genetic algorithm can derive quite a large number of features from an image as compared to that of other algorithms. It is also put into application for dimensionality reduction [15].

**Usage of Fuzzy Logic.**
The fuzzy logic is quite in use for classification of diseases and even the rawness or ripeness of fruits. Various techniques such as RGB color technique can be used to extract the features and after that that the fuzzy logic can be implemented foe classification.[16]

**Artificial neural network and identification of diseases.**
Detection of diseases in cucumber plant with the implementation of artificial neural network [17]. This algorithm has up to 89.9 percent accuracy in the identification. It is one the most used algorithms of the times due to its easy implementation and application. Also it has a fine of identifying errors which do not increase with increase in the number of errors.

**Naïve Bayes algorithm.**
This algorithm is mainly used for identification of fungal infection. This algorithm too has a very high prediction ration comparative to its contemporary. In the paper [18] we studied how the optimality of the Naïve Bayes algorithm can be enhanced under the Gaussian distribution. The algorithm is an excellent option for classification

**Improvisation in our work:**
We studied the works done in each of the papers and reasoned out how the various algorithms work and function in specific condition, implementing the best suitable for the tomatoes and accordingly we choose our algorithms.

3. **PROPOSED METHODOLOGY**
Diseases in Plants are a major concern to the farmers these days. Many a times, the farmers are not sure which pesticide or insecticide is needed to treat a particular diseased plant because they are not sure of the type of disease. This results in sprayin g wrong pesticides, damaging the plants which affect the plant yield.

To overcome with this problem, we have come up with a solution of developing a system that easily identifies some common diseases that occur in a tomato plant by merely examining the leaves of the plants.

These diseases are:
1. Early Blight
2. Bacterial Spot
3. TYLCV

Through image processing and machine learning algorithms, we aim to classify such diseases and generate a model that would provide an easy and accurate way of determining the plant disease through on click of an image of the affected plant leaf.

This system is not only beneficial to the farmers in saving the crops, but also in saving money by buying only right kind of pesticides suitable to treat the particular disease.

As the system does not involve any heavy machineries and electricity, the system proves to not only be a cost-effective solution, but also an environment-friendly one.

4. **SYSTEM ARCHITECTURE**
Architecture Structure depicts how the system interacts and the control flows from one point in the cycle to another. There we will discuss the hardware control flow of the system right from capturing from the image to detection of the disease and displaying it.
The figure 1 below shows the hardware and software control flow of the system as a whole.

![System Architecture Diagram](image)

**FIGURE 1.** SYSTEM ARCHITECTURE

4.1. *Image Capturing through Camera*

The images of the diseased plant leaf are captured via a mobile or a digital camera. The image captured is then transferred to the system and it is followed by the process involving the image processing stage. The resultant image is given as an input to this software system. This image forms our testing data which will determine the accuracy of our system.

The image before being actually tested on our Machine Learning model is first resized, then recolored, and made fit using numerous techniques. This image is ready for testing.

4.2. *Dataset Collection and Creation*

The dataset is a collection of huge amounts of data that is unprocessed and needs to be trained in order to yield some useful information out of it. The dataset used in our system is collection of images of various plants leaves that either are healthy or fall into one of the diseased categories:

1. Early Blight
2. Bacterial Spot
3. TYLCV
The database needs to be huge in order to ensure maximum accuracy and precision of our disease identification model. We have a total of 200 leaf images: 50 each for healthy, early blight, bacterial spot, and TYLCV. All these images are resized and refined to one specific quality and dimensions so as to have a uniform dataset.

This dataset forms our training data which regulates the platform to begin with the digital image processing part.

4.3. Digital Image Processing
It is a whole big mechanism comprising of various stages and algorithms. If we look from the entire process as a whole, the function of this stage is to:
1. Perform training of the images that are pre-composed and collected by us and stored in the form of our dataset.
2. Perform testing on the image of the plant leaf captured by us to know if the leaf is diseased or not.

The dataset collected forms the training data which is trained against our image processing model. This model is then saved and used to test the images taken in by the camera. The Web interface comes into requirement when we need a user interface wherein a user needs to upload the captured picture into the front-end and the model is pre-trained by the dataset of images in the back-end. The result is generated on the user interface without needing the user to navigate between training and testing phase of the system. This interface renders easy and smooth flow of control and the user does not need to know the entire mechanism behind the Plant Disease Identification System.

5. PROCEDURE
The Digital Image Processing is a combination of a number of steps and algorithms that go together in a controlled flow manner. The flowchart as shown below depicts the various stages that the images goes through before the final result is produced.
6. PRE-PROCESSING
This step involves processing the test image in order to bring it to the size, colour and quality of the images comprising our dataset. This involves various stages through which the image goes. These stages are:

1. **Image Resizing:** The dimensions of the image are brought equal to the dimensions of the training images by using the `imresize()` method in MATLAB. Image resizing is a crucial step as the pixel values may change if the dimensions of all the training as well as the testing images are not the same.

2. **Smoothening:** The smoothening of the image renders the pixel values to gradually even out to all the points of the image so as to allow a smooth image. Along with this the image also gets converted from colored to grayscale image using the function `RGB2GRAY()`.

3. **Noise Filtering:** The noise is the unwanted extras that are present in the images that make feature determination and extraction difficult. Thus the process of noise filtering involves removal or averaging of the pixel values that add noise to the image. The process used in our system to ensure noise removal is ‘Median Filter’.

![Figure 3. Execution Flow](image)

**Figure 3. Execution Flow**

![Figure 4. Pre-Processing](image)

**Figure 4. Pre-Processing**
7. Feature Extraction

Feature Extraction is a method used for dimensionality reduction which helps in representing into a compact feature vector, the parts of the image which are interesting. This process results to be very helpful when the sizes of images are large and for the faster image matching and retrieval, reduced feature representations are required to complete tasks quickly.

The Feature Extraction techniques we use in our system are as this:

a. Histogram of Oriented Gradients (HOG):

It captures characteristics by calculating the occurrence of the gradient orientation. The HOG as shown in Fig. 5 is used to divide the image into unique parts and computes a histogram of gradient orientation representation over the images. HOG are enforced in huge object recognition fields like recognition based on face and in our project, for plant leaf recognition.

The histogram of oriented gradient is being practiced in various study centers with amazing and outstanding performance and working in fields like pedestrian detection. A fast arithmetical approach was build and many unique elements that are responsible the HOG’s performance were calculated to build a HOG descriptor consisting of fine scale gradient.

![Figure 5. Histogram of Oriented Gradients (HOG) with its features](image)

b. Gray Scale Co-occurrence Matrix (GLCM):

The texture filter is implemented to show and calculate the view of texture which is statistical found on the image histogram. These are used to provide appropriate result about the texture of an image but it unable give data related to the shape that is the spatial relationship between the pixels of a given image. Feature extraction requires reducing the number of resources needed to regulate a huge set of information.

The extraction of GLCM is based on a statistical texture analysis; this texture is figured out from the numerical distribution of observed mix of intensities at the specified position to each other in the image. The GLCM feature is useful in motion estimation of videos and real time pattern of Recognizing operations such as Military and Medical Applications.

![Figure 6. Leaf images](image)

| Table 1. GLCM Extracted textual features for two different leaf images. |
|------------------------|------------------------|------------------------|------------------------|------------------------|
| Feature               | Leaf 1                | Leaf 2                | Leaf 1                | Leaf 2                |
|------------------------|------------------------|------------------------|------------------------|------------------------|
| Angle (in degrees)     | 45°                    | 45°                    | 90°                    | 90°                    |
| Autocorrelation        | 0.992                  | 0.992                  | 0.992                  | 0.992                  |
| Contrast               | 0.992                  | 0.992                  | 0.992                  | 0.992                  |
| Correlation            | 0.992                  | 0.992                  | 0.992                  | 0.992                  |
| Homogeneity            | 0.992                  | 0.992                  | 0.992                  | 0.992                  |
Figure 6. GLCM

The output of this phase is a vector or a matrix representing various gradient descent and various useful features that further get analyzed and classified.

8. Classification
The final stage of our Image Processing Phase is the training of the dataset and testing of the images against the trained model. The algorithm used in this classification model is the KNN. KNN algorithm can be explained as supervised machine learning algorithm as it can be implemented to find solutions of both the classification and regression problems. This algorithm begins with making an assumption that the things with more similarity are existing in close proximity, or we can also say that similar things are near to each other.

In KNN algorithm we first start with the loading of the data and then initializing K to the selected number of neighbors, then for each example in the data we find the distance between the query example and the given current example from the given data. Then the data collected is sorted orderly from smallest to largest according to the distances, later we pick the first k entries from the sorted collection and take the labels of the selected k entries.

If there is regression then the algorithm returns mean and in case for the classification the mode value is returned. Hence our images go through this algorithm and get classified according to the disease category they belong to. It is a very clean and precise process which produces accurate results.
9. Web Interface
The complete process of model training and performance is performed in backend, so for the easy user interaction we use frontend application which helps us in analyzing the images that are uploaded from the sources like an external camera or downloaded from the internet. These test images are easily analyzed with help of backend processes and are represented using this user interface, as we test these images and represent the result soon after that. Thus the Web Interface is interlinked with our model at the backend and the user’s camera/phone in the frontend.

10. Conclusion
The proposed methodology in the following tomato plant leaf disease detection system focus on generating an advance and efficient system which makes the process of creating high yield of tomato much more easier for the farmers. The project aims to detect the most common diseases occurring on a tomato leaf, namely early blight, bacterial spot and curl using image processing technique under upbringing technology i.e., machine learning. In easier terms, the farmer will be able to accurately detect the type of disease a particular plant is having using the image of the plant. The proposed system is based on four important modules namely:
- Pre-processing.
- Segmentation
- Feature extraction.
- Classification using KNN.

In this study, we describe the comparison of our system with preexisting systems with proper methodology and implementation. The proposed systems functionality is better than existing disease detection system as it is able to generate a more accurate and precise result with easier and faster implementation. It aims to make the life of farmers easier. The system can be a boon to the agricultural sector as it advances the crop production and management process, as agriculture is of the major reason to facilitate growth of per capita income of our country.

11. Future Enhancement

11.1. IoT Enhancements
The IOT is an flourishing domain in the industry that dynamically integrates the communication between various devices or objects by using a variety sensors of through the internet highway in a seamlessly integrated and remote manner. IOT implements devices which function smartly and utilize the internet to generate advance and progressing solutions to different problems in modern era. IoT devices can be used to automate the spraying of the particular disinfectant to protect the plants from disease. After detection of the disease the user can select the particular type a, b or c which medicine he wants to use and that will be sprayed automatically on the plant.

11.2. Web-Interface Enhancements
The whole project can be put up on the internet and user can simply sit at home and use the system to detect the disease and spray the required disinfectant. The IoT enhancements can also be implemented
using the web interface and just by clicking on the button the user will be able to spray the medicines. The interface will connected with the internet and then to the database.

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