Banana Leaf Disease Detection With Multi Feature Extraction Techniques Using SVM

MSc Research Project
Data Analytics

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Banana Leaf Disease Detection With Multi Feature Extraction Techniques Using SVM

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Abstract

Farming is how the majority of people in developing countries make a living. As a result of climate change, farmers face numerous challenges. Plants that are farmed are susceptible to various diseases. Not many farmers are able to obtain the expert opinion of an eyewitness. The sickness must be detected as soon as possible using the simplest method. A method of detecting these diseases can be implemented by leveraging the technology of machine learning. This article describes an automated method that uses color, shape, and texture information to detect illnesses in banana plants. Data classification methods include Support Vector Machine (SVM) Classification Techniques. The proposed study displayed an average accuracy of 90 Percentage to distinguish between two types of diseases namely Sigatoka and Xanthomonas by combining GLCM and NGTDM features.

1 Introduction

Agriculture is still one of the largest industries in the world and employs around 27 percentage of the world population . The yield of a farm is the main source of income for such a large population. Recent problems such as climate change are affecting the crops to a very large extent with new diseases affecting the plants resulting in lower yields. One such plant is the banana plant. Banana is an important plant in the world that is of great importance pertaining to its energy values. It is a major crop in some of the developing nations in the world. This plant is susceptible to various diseases that require early detection for curing them. Detection of diseases using machines has generated a huge potential in the agricultural industries (N. Ani Brown Mary, A. Robert Singh Athisayamani S, 2020). Many modern tools such as smartphone-based applications are being developed to inspect the crops and their probable yield (Jogekar Tiwari, 2021). This study investigates the identification of such diseases using leaf images. This study leverages machine learning technology for disease detection which can assist the applications already in development.

1.1 Motivation and Project Background

The most significant fruit crop that is commercially farmed is the banana, which is used as a dessert and a staple diet in several regions of the world. It is one of the most significant fruit crops in international trade for generating foreign exchange in several African nations. The primary barrier to the effective, high-quality production of this crop is the diseases brought on by fungi, bacteria, and viruses, and nearly all commercial cultivars of banana are extremely vulnerable to a number of lethal diseases (Deenan et al, 2020). The issue of managing disease in bananas was made more difficult by the viruses' rapid development of tolerance to new pesticides (Pukale D D, 2018). To assist farmers in maintaining the health of their banana crop and to regularly notify them on any diseases that have been found in the leaves of banana trees. Additionally, offer farmers preventative measures for the anticipated sickness. To ensure that his crop's produce reaches its optimum potential and that the disease does not spread further. The technology effectively identifies, detects, and offers corrective action (rectification) for diseases in banana leaves.

1.2 Research Questions

How does a Support Vector Machine With multi feature extraction techniques, GLCM and NGTDM , that help in detection and classification of banana leaf disease.

1.3 Research Objectives

1. To verify the understanding of support vector machine in leaf disease detection.
2. Implementing GLCM, NGTDM feature extraction techniques for the image feature extraction.
3. Comparing GLCM, NGTDM and GLCM + NGTDM feature extraction techniques for accurate values.

1.4 Paper Plan

This report is organized into following sections where section 2 is about literature review and it's comparisons. Section 3 discusses the methodology employed in the study . Section 4 discusses about Design Specification. Section 5 discusses the implementation of the methodology that has been developed. Section 6 discusses about Results and Discussion The last section 7 discusses about conclusion and future works.

2 Literature Review

This section of the report investigates the use of the presented methods of feature extraction and the machine learning technique. It thoroughly critiques the methods that are implemented in the study.

2.1 Support Vector Machines in Agriculture

The support vector machines are a type that minimises the risk of the structure that are based on learning algorithms. This is known to be a very popular that is used as a learning algorithm. According to Ani Brown Mary et al. (2021) the Support Vector Machines are machines that are commonly used in various fields like the information that are retrieval and the classification of text in the last 10 years. The Support Vector Machines are used to help classify the data of the agricultural sector. This is a machine that is used to get better solutions to manage the crops in a better way. There is increased production and automation of the systems that have been used of the internet and data of mining. There is climatic change and farmers knowledge has been increasing that make the use of internet based and artificial intelligence farming that needs to be done (Saranya et al., 2020). There is an Implementation of artificial intelligence to get the precision for future values of moisture sensors. The precision of agriculture in order to detect the bananas and the full-grown bananas. There are other systems that help determine the amount of water by using the systems that are fuzzy and networks that are neutral. There are also various parameters used in order to help in the determination of the systems of irrigation. This consists of the data of the environment that includes the ambient, temperature, humidity, and the moisture of the soil. There are also other variables that are known to be additional to the irrigation systems. According to Wang et al. (2021) determining the control of the irrigation that helps with the use of water for crop demand. There is also the evaporation of the soul, the condos of the weather and the forecasting of the agricultural sector of water that uses the LS-SVM to help the accuracy improve and the speed in the implementation of the process forecasting. There is automated irrigation that is used by proposing the idea of integration of the quantity of the water predictions.

2.2 Analysis of GLCM and NGTDM feature extraction

This technique is used to analyze the pictures and improve the quality that is not processed yet and is known as image processing (Raja and Rajendran, 2022). These are the raw images that one may find on the deployed cameras that have been obtained from aircrafts, satellites, space shuttles and just the daily routine for various objectives. There are plenty of processes that have come out of image processing methods that have been developed in the last year's that have passed. There are various approaches that have been explored for the processing of images and are received from different armed forces for flights for scouting. There are various factors that are accessible that are effortless for the prevailing personnel processors and the big dimensional equipment's that also play a fundamental role in the popularity of the techniques of the processing images. These methods have been used on the pictures used for the analysing of farming pictures like fruits and vegetables for an acknowledgement or categorisation causes. There are schemes used for the detection of the fruit that is implemented in the form of describer of the text in an image. This is a scheme that comprises of the ability for the description of low-level type of images characteristics or contents of the pictures of the fruits. There have been several techniques that was proposed to categorise and detect of the pictures of the fruit on the basis of the colour and the shape. There are dependents on the texture and the colour of various fruits for the growth. A fruit's colour and growth is known to be the primary quality of the natural descriptions (Rout and Parida, 2019). There are factors that also play a very important role and character in the perception of the image or picture.

2.3 Role of SVM in detection and classification of banana leaf diseases

There are plenty of diseases that affect crops in general. This leads to the losses of production which is in turn a threat to the security of food (Jogekar and Tiwari, 2020). There has been a human visual examination that gives a huge room for error only depending on where the farmers are trying to detect diseases through the inspection of visuals that has a big chance in error in different cases that resort to experts in some cases. This needs a lot of time, effort, and money. There are a lot of colours and artificial neutral networks which are diseases that are affecting the banana and in turn the leaves of the banana. In this report, there is the conversion of an image from RGB to gray and then the HSV colour features. This gets extracted from histogram of the template of colour that also includes the Mean and Standard deviation. This feature is known to create the base of knowledge and is used later as a classifier in help for training. There are programs that have been used to help classify this banana leaf disease (Narayanan et al., 2022). The most important thing to remember is that the system has a lack of segmentation process that is very important when removing or separating the injured or bad part of proper part of the leaf in the image. If the images are good, there is still a possibility of the leaf having the disease. It is very necessary to use segmentation method, but it is also very clustering when there are different diseases that need to be separated from the good and healthy part of the leaf. There is the first part of the proposed plant disease that has been detected on the system in the process of training. The images of the plant have been detected at this stage. It is obtained while using a digital camera. It is then put through a pre-processing of techniques that are then applied to the image. According to Lin et al. (2021) there are useful features that are used in the extraction while using the extraction feature which is being used as an example. This support vector machine algorithm is then proposed to learn the machine algorithm. The images are first received after it is captured with a digital camera. Then, there are techniques that are referred to whilst the training period. It is first applied and then the case will go into the infected or healthy categories. This will be detected by the Support Vector Machine (SVM). This is a process that aims to improve the image and helps to remove noise and objects that are unwanted. It is basically done to improve the visual appearance and give an effect that is

2.4 Literature Gap

The gap in the literature helps in identifying the areas that are unexplored in the discussion of the Research work. The untapped areas of the research reflected on offering opportunities for the future researcher to improve the future studies and research work that are going to be published on a similar topic. Reflecting on the research work on the topic Banana Leaf Disease Detection with Multiple Feature Extraction Techniques using SVM, the researcher has only focused on identifying the techniques using SVM in order to detect the disease in the banana plant. It might not be applicable for detecting other plant diseases in crop production. The agriculture industry of India is a vast area where various kinds of plants are produced. The detection of the disease and the methods of implementing various solutions might not be applicable to other plant disease detection. The different countries have different environmental specifications and climate change issues that create various other challenges that have not been discovered in the existing literature.

2.5 Comparison of the Techniques Used in Disease Detection Plants

Comparison of literature on the different data-set, classifications, features, segmentation and results obtained in table 1. By observing the comparison table, Bashish et.al (2010) achieved a high accuracy of 93 percentage with Neural Network in classifying disease in a banana leaf. The next highest accuracy in the comparison result is by Camargo et.al (2008) for SVM model achieved 95 percentage accuracy with threshold Segmentation, shape, texture and frequency. Guru et.al (2011) obtained an accuracy of 88.9 percentage using neural networks for classification. But for the research by Chaudhari V (2020), a low accuracy of 85 percentage was observed.

Author	**Models**	**Accuracy**
Chaudhari V (2020)	(SVM) Classification, feature extraction	**85%**
Camargo et.al (2008)	SVM with Threshold Segmentation Shape + Texture + Dispersion + Grayleaves + Histogram of Frequencies	**92.1%**
Guru et.al (2011)	Neural Network with Morphological Operation Technique Texture Features Probabilistic	**88.59%**
Bashish et.al (2020)	Neural Networks with K-means Segmentation Texture Features	**93%**
N. Ani Brown Mary, A. Robert Singh & Athisayamani S (2020)	KNN classifier with Gabor Feature Descriptor	**98.2%**
Krishnan et al (2022)	Convolutional Neural Network	**93.45%**
Narayanan et al (2022)	Hybrid Convolutional Neural Network	**99%**
Lin et al (2021)	Combination of Dilated and Multi-scale convolution	**96.39%**

Figure 1: Comparison of Literature Review of Banana Leaf Disease.

In conclusion, Based on the results that are reviewed and found gaps in the related work that there is a evidence and there is a need to develop identification of disease detection using multi feature extraction techniques. Even in the part of phrasing questions and answer, and in research objectives. For addressing the gap and also to support the agricultural department and also the farmers. In the following chapter presents research methodology used to develop the detection and classification model that support the business entities , farmers that uses precaution for the disease. float

3 Methodology

This section of the study discusses in detail the methodology that has been employed in the study. A methodology for a study can be a Knowledge Discovery Data Mining (KDD) or a CRISP-DM methodology. As this study is pertaining only to the knowledge discovery, KDD approach of methodology is used in the study. Figure 1 above depicts

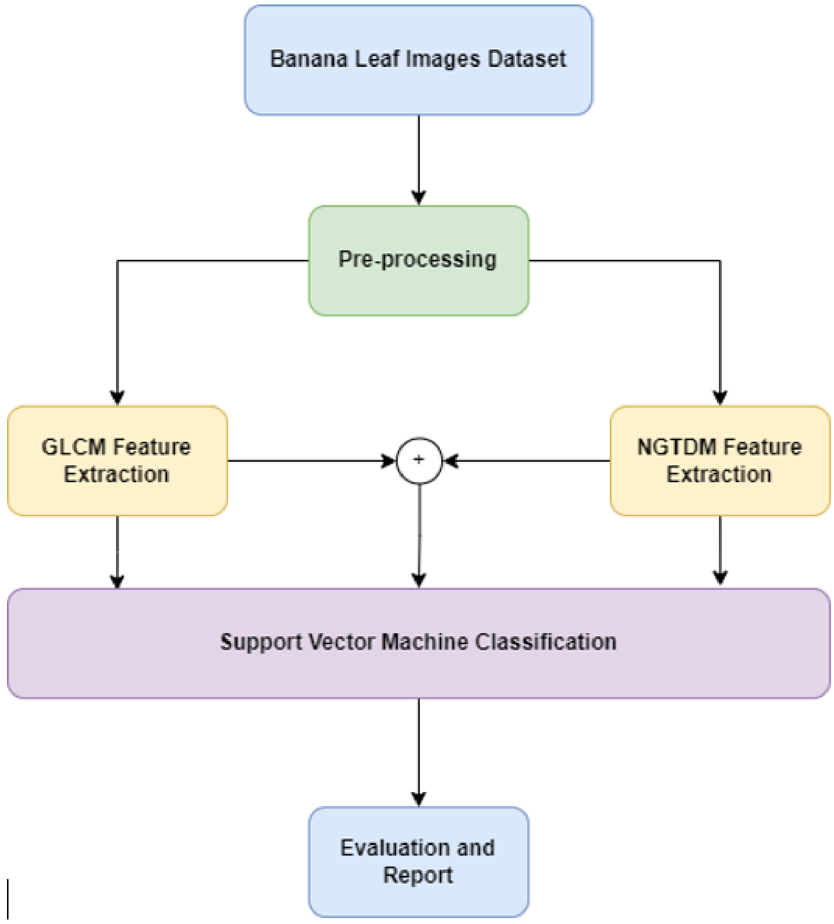

Figure 2: Methodology

the methodology that has been implemented in the study. It consists of mainly four parts viz. the data set, pre-processing, feature extraction, and classification. They are discussed below.

3.1 Dataset

The dataset that has been used in the study consists of 1289 images of banana leaves that are either healthy or diseased. Out of the 1289 images, 155 images correspond to healthy leaves, 320 images represent banana leaves with Sigatoka disease, and the remaining 814 images represent banana leaves with Xanthomonas disease. The images are coloured in RGB Colo space. From the dataset, it can be observed that the classes are imbalanced. To ensure the reliable classification of the images, the classes have to be balanced.[1]

[1]https://data.mendeley.com/datasets/rjykr62kdh/1

3.2 Data pre-processing

To get started with the classification process, the data is pre-processed to achieve better computation and analysis. In the study, the images are pre-processed using following steps.

1. Image Resizing
   To ensure all the data that will be used for processing be of equal dimension, the images in the data set are resized.

2. Image Sharpening
   To help the algorithm to detect edges reliably, the images are then sharpened using a sharpening filter.

3.3 Feature Extraction

The features from the images are extracted using two techniques viz. Grey Level Co-occurrence Matrix (GLCM) and Neighbouring Grey tone Difference Matrix (NGTDM).

GLCM

GLCM feature extraction involves extracting features such as Energy, ASM, Contrast, Homogeneity, Correlation, and Dissimilarity for the greyscale version of the original image. Energy: The homogeneous patterns in an image are measured using Energy. High value of it indicates presence of pairs of high intensities neighbouring each other at high frequencies. It is given by the equation below.

$$energy = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} (p(i,j))^2$$

ASM: It is the square of the energy value for the image.

$$ASM = (energy)^2$$

Contrast: The variance in intensity in an image is measured as its contrast. High value of contrast indicates high variation. It is calculated by the equation given below.

$$contrast = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} (i-j)^2 p(i,j)$$

Homogeneity: It measures the similarities present in the image and is given by the equation below.

$$homogeneity = \sum_{i=1}^{N_g}\sum_{j=1}^{N_g} n.p(i,j)$$

Correlation: It measures the similarity in the grey level values with the respective voxel in a GLCM.

$$correlation = \frac{\sum_{i=1}^{N_g}\sum_{j=1}^{N_g} p(i,j)ij - \mu_x\mu_y}{\sigma_x(i)\sigma_y(j)}$$

Dissimilarity: It is the measure of difference in the similar and different intensity values in an image.

$$dissimilarity = \sum_{i=1}^{N_g}\sum_{j=1}^{N_g} |i-j|p(i,j)|$$

NGTDM

NGTDM feature extraction involves extracting features such as Coarseness, Contrast, Busyness, Complexity, and Strength.

Coarseness: It is the measure of spatial change in the texture present in an image.

$$coarseness = \frac{1}{\sum_{n=1}^{N_g} p_i s_i}$$

Contrast:

$$contrast = (\frac{1}{N_{g,p}(N_{g,p}-1)}\sum_{i=1}^{N_g}\sum_{j=1}^{N_g}(i-j)^2 p_i p_j)(\frac{1}{N_{v,p}}\sum_{i=1}^{N_g} s_i)$$

Busyness: It measures the change in intensity values in adjacent pixels.

$$busyness = \frac{\sum_{i=1}^{N_g} p_i s_i}{\sum_{i=1}^{N_g} \sum_{j=1}^{N_g} |ip_i - jp_j|}$$

Complexity: Indicates the rate of change in the grey level intensity in the image.

$$complexity = \sum_{i=1}^{N_g} \sum_{i=1}^{N_g} |i - j| \frac{p_i s_i + p_j s_j}{p_i + p_j}$$

Strength: It measures the primitives in an image.

$$strength = \frac{\sum_{i=1}^{N_g} \sum_{j=1}^{N_g} (p_i + p_j)(i - j)^2}{\sum_{i=1}^{N_g} s_i}$$

3.4 Classification

This study utilizes the Support Vector Machine (SVM) classifier for the classification of the images obtained from GLCM and NGTDM. As discussed above, the dataset has imbalanced classes. To ensure the reliable classification of the features extracted, classes have to be balanced. This study makes use of the Synthetic Minority Oversampling Technique (SMOTE) to oversample the classes that are in minority. As the dataset has 155 images corresponding to the healthy class, and 320 images corresponding to the Sigatoka disease class, these classes have to be oversampled to match with 814 images of the Xanthomonas disease class. float

4 Design Specification

The efficient design flow combines different feature extraction technique with augmented data as shown in Fig. 3.

1. Data set is downloaded from the website
2. Performed Data Augmentation on the data set
3. GLCM, NGTDM and GLCM+NGTDM feature extraction is performed individually
4. SVM modelis applied on each feature extraction technique and accuracy is calculated for each.
5. In the end classification report is acquired that contain mitres precision , recall and f-1 score.

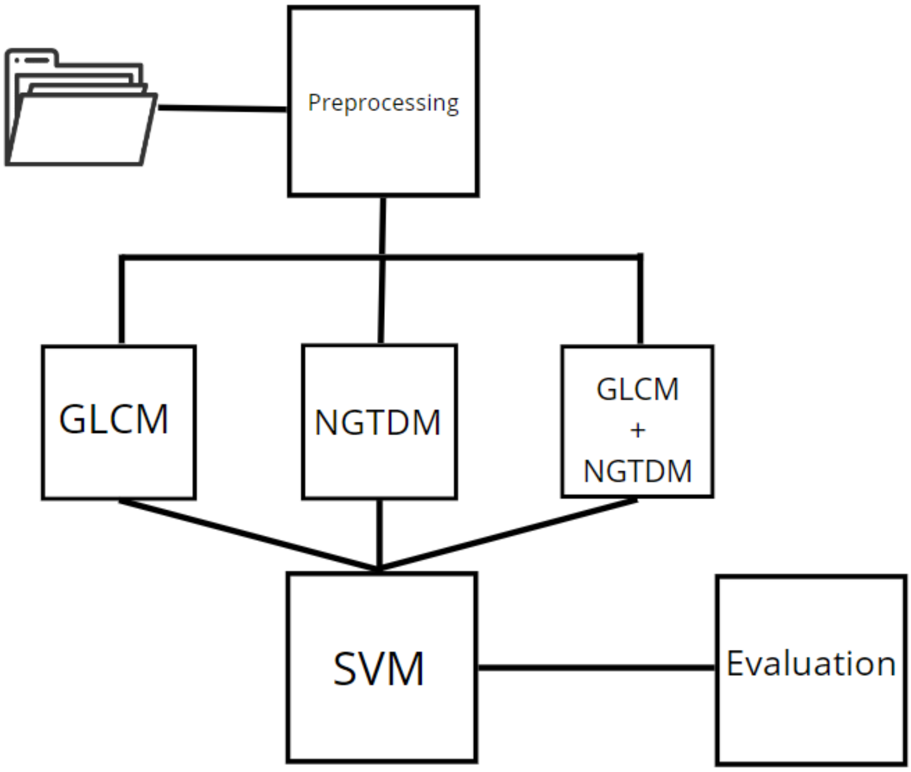

Figure 3: Design specification

5 Implementation

This study has been implemented using the Python programming language in the Jupyter Notebook. Implementation of the modules described in the methodology is done as follows. The images in the dataset are present in '.jpg' format in folders named with the class of diseases they belong to. The images are read using the open() function of the Python. After the images are imported in the workbook, the images are resized to 224x224 pixels. Once the images are resized, they are sharpened using a sharpening filter shown in figure below(Figure 4). The sharpening is done via the 2D convolution of the image and the filter.

```
[[0, -1, 0],
 [-1, 5, -1],
 [0, -1, 0]])
```

Figure 4: Sharpening Filter

5.1 Feature Extraction

GLCM feature extraction is done using the greycomatrix() function of the skimage library available for python. The features that need to be obtained from the image are also given as input to the function. The output of the function is a matrix consisting of features corresponding to each pixel in all the images of the dataset. The data is then normalized using the min-max normalization with the MinMaxScaler() function of the 'sklearn' library. NGTDM features are extracted using a mask and finding the convolution of the mask with greyscale image. Features are calculated using three terms calculated from the convolution. These features are also normalized using the MinMaxScaler() function.

5.2 SVM

After the feature extraction, the classes are balanced using the SMOTE method with SMOTE() function of the sklearn library. The balanced feature vector is then subjected to splitting the data into two sets viz. training set and the testing set. The SVM model is trained using the training data and is evaluated using the testing data. Training data consists of 80 float

6 Results and Discussion

6.1 Experiment 1: Exploratory Data Analysis(EDA)

On Banana Leaf dataset exploratory data analysis is performed which is the goal of this experiment 1.The dataset consists of 1289 images categorized into 3 categories with 155 images of Healthy leafs, Sigatoka 320 images and Xanthomonas with 814 images. It is observed that in EDA healthy images are ves less compared to sigatka, Xanthomonas and also while comparing sigtoka with Xanthomonas, sigatoka are very less in image count. Later to avoid imbalance of the data, SMOTE is used to balance the dataset .Figure 5 shows bar plotted dataset with 3 classes

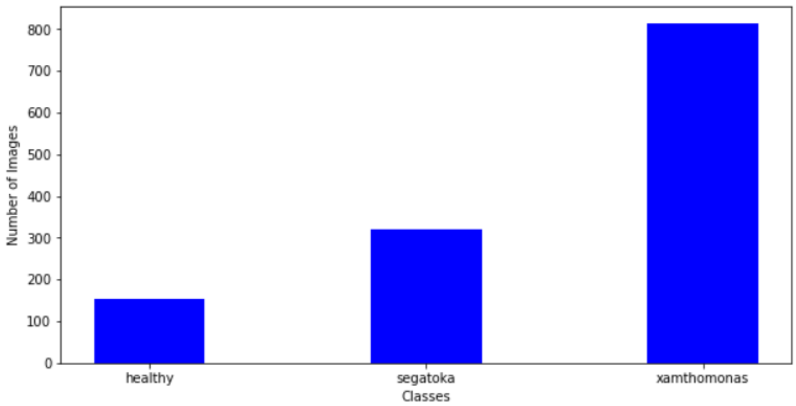

Figure 5: Data distribution of banana leaf dataset

6.2 Experiment 2: Implementing GLCM

The aim of this experiment is to Implement GLCM. For Gray level co occurance matric properties like dissimilarity,correlation,homogeneity,contrast, ASM, energy are taken and images are read. In the function generateGlcmAgls default values are given as arguments and for especially implimenting GLCM , greycomatrix function is used and features are returned, With the different property names and angles that are in documentation are taken, then appended. Pandas dataframes are created for viewing GLCM features data. The null values are then checked if exists any.Using describe() basic statistical values are checked from the features.

For the normalization MinMaxScalar() is used. To balance the imbalanced data we have used SMOTE() then train-test-split() is used for the evaluation of the model where test size is 0.15 and random state = 42. Support vector classification with different properties are tested ie., changing the c values to 20 or 100, gamma ='scale',gamma = 'auto',kernel= 'rbf',kernel= 'linear',max-iter = 500, decision function shape ='ovo'. At the end properties with gamma='scale', C = 100, kernel= 'rbf' gave an accuracy of 78 parentage , which is the highest than with other properties with accuracy 55, 61,71,68. Below image shows the heat chart plotted for truth and predicted values.

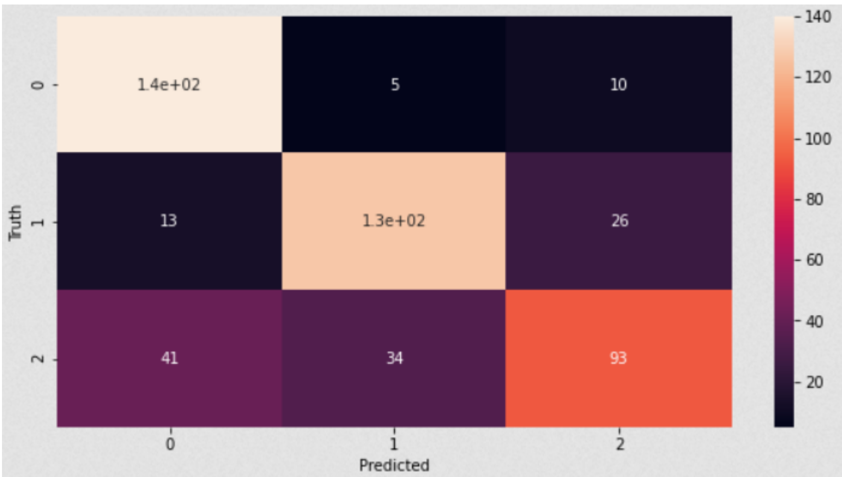

Figure 6: Heat chart for GLCM accuracy

	precision	recall	f1-score	support
0	0.74	0.86	0.80	121
1	0.78	0.84	0.81	121
2	0.82	0.64	0.72	125
accuracy			0.78	367
macro avg	0.78	0.78	0.78	367
weighted avg	0.78	0.78	0.78	367

Figure 7: Classification report for GLCM

6.3 Experiment 3: Implementing NGTDM

In this experiment NGTDM is implimented. For neighbourhood grey tone difference matrix different properties like Coarseness, Contrast, Busyness,Complexity,Strength are taken and images are read. In the function generateNgtdmFeatures that returns the features intensity masking in the imageXOR function which returns XOR image, here pixels of the image are inverted and genNgtdm where the sum of the absolute differences of masked image for grey level is stored of a format of matrix. Pandas dataframes are created for viewing NGTDM features data. The null values are then checked if exists any.Using describe() basic statistical values are checked from the features.

For the normalization MinMaxScalar() is used. To balance the imbalanced data we have used SMOTE() then train-test-split() is used for the evaluation of the model where test size is 0.20 and random state = 42. Support vector classification with different properties are tested ie., changing the c values to 20 or 100, gamma ='scale',gamma = 'auto',kernel= 'rbf',kernel= 'linear',max-iter = 500, decision function shape ='ovo'. At the end properties with C=10, gamma=50 gave an accuracy of 73.61 parentage , which is the highest than with other properties with accuracy 65, 51,54,60. Below image shows the heat chart plotted for truth and predicted values.

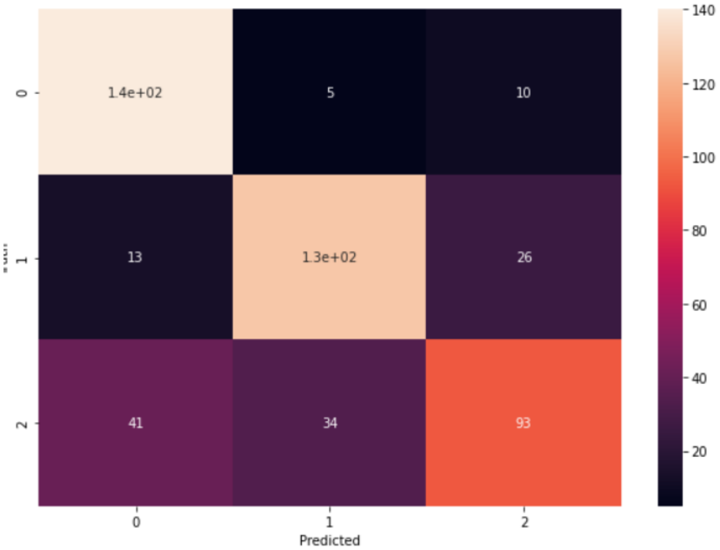

Figure 8: Heat chart for NGTDM accuracy

	precision	recall	f1-score	support
0.0	0.66	0.87	0.75	155
1.0	0.75	0.82	0.78	166
2.0	0.73	0.45	0.56	168
accuracy			0.71	489
macro avg	0.71	0.71	0.70	489
weighted avg	0.72	0.71	0.70	489

Figure 9: Classification report for NGTDM

6.4 Experiment 4: Implementing GLCM+NGTDM

In this experiment NGTDM+GLCM is implemented. From the above experiments the ngtdm and glcm features data re concatenated into one axis and all dublicates are dropped. The data is then checked for null values and unnecessary colunmn values are dropped.For the normalization MinMaxScalar() is used. To balance the imbalanced data we have used SMOTE() then train-test-split() is used for the evaluation of the model where test size is 0.20 and random state = 42. Support vector classification with different properties are tested ie., changing the c values to 20 or 100, gamma ='scale',gamma = 'auto',kernel= 'rbf',kernel= 'linear',max-iter = 500, decision function shape ='ovo'. At the end properties with C=100, gamma=50 ,kernel= 'rbf' gave an accuracy of 90.38 parentage , which is the highest than with other properties with accuracy 70, 74,80,79. Below image shows the heat chart plotted for truth and predicted values.

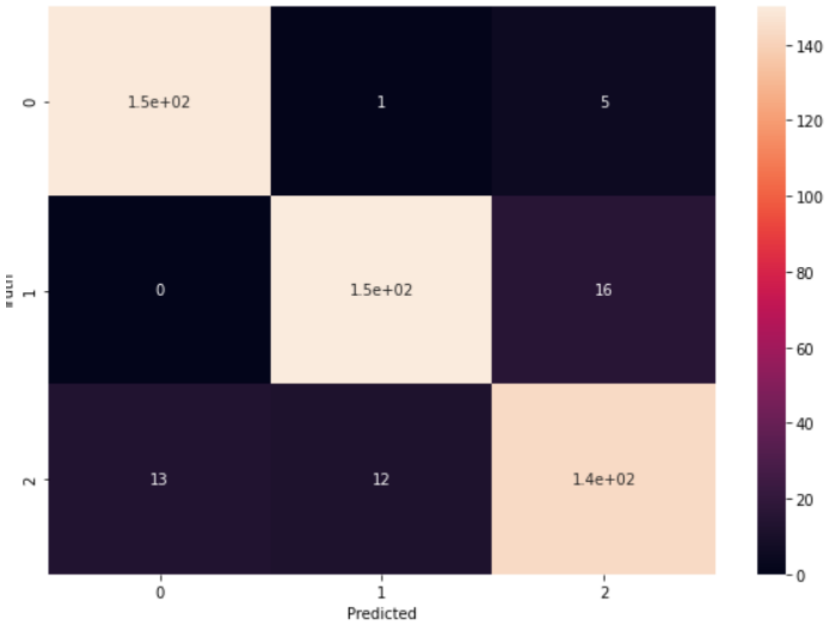

Figure 10: Heat chart for NGTDM+GLCM accuracy

	precision	recall	f1-score	support
0.0	0.92	0.98	0.95	155
1.0	0.92	0.87	0.90	166
2.0	0.86	0.85	0.85	168
accuracy			0.90	489
macro avg	0.90	0.90	0.90	489
weighted avg	0.90	0.90	0.90	489

Figure 11: Classification report for GLCM+NGTDM

Model	Accuracy (%)
GLCM + SVM	77.92
NGTDM + SVM	70.0
GLCM + NGTDM + SVM	90.00

Figure 12: Feature extraction techniques results

7 Conclusion and Future Work

Banana plant which is susceptible to various kind of diseases that affect its leaves and the fruits. Being a largely grown plant in many developing countries, it is an important source of employment. Detecting diseases affecting a plant early is very crucial for its treatment to avoid it from incurring losses to the farmers due to low yield. This study addresses the issue of detecting the disease with the help of machine learning technique of SVM. GLCM and NGTDM features are extracted from the leaf images to infer about the type of disease they are suffering from which are then modelled upon using the SVM classifier. The classification results show that these features are really helpful in detecting the disease that is affecting the plant. The model implemented achieved the highest accuracy of 90 percentage with the combination of GLCM and NGTDM features. A comparison of the results obtained from the study with other literature listed in figure 9 shows that the model outperformed all the past models that are compared with SVM and other feature extraction techniques.

The developed model showed a very good performance. The developed model can be implemented on other plants as well to detect diseases. The developed model can be tested to detect other diseases such as Pestaliopsis leaf blight and Cordana that can affect the banana plant. Also with the improved dataset that have clear images which can be used for clear segmentation of the leaf and accuracy can be increased to the maximum.

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