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Agronomy with IoT Devices: The Smart Solution for Detection of Diseases of Betel Leaves

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Abstract The growth of the entire population in the entire world and scarcity of food crops are the most challenging concept nowadays and for solving these challenges, new mechanization like artificial intelligence, Internet of Things and the mobile internet are used for solving this above-mentioned real- life problem. From 2019 onwards, a current perspective regarding Intelligent Agronomy has been focused on. For this smart system, Internet of Thing (IoT) is the column pillar because sensor devices are being connected to perform various basic tasks. Different sensors are used in the smart irrigation system which is based on smart controllers and detectors for vigilance of water line, watering efficacy and environment. Automatic leaf disease detection is also a very important concept for monitoring the growth of food crops and other plant leaves with medicinal value. This system also detects the symptoms of the disease in the plant leaves automatically. In the proposed decision- making system the authors have collected a set of betel leaf images and have utilized image content characterization and Support Vector Machine (SVM) classifier. Different stages like initialization, bifurcation, eradication of characteristics and orderly arrangement have been involved in image processing mechanisms for analyzing decisions. At the time of processing, an input image is being rescaled as per requirement. Authors of this research paper have eliminated color and surface characteristics from input image sets for classification and training. The proposed system will be able to analyze the test images automatically for making decisions about the leaf whether it is abnormal or good.

Keywords Internet of Things (IoT), Smart Agronomy, Support Vector Machine (SVM) Classifier, Python 3.9, Betel Leaves

1. Introduction

The primordial occupation of entire nations throughout the world is agronomy. Reports say that 80% population of India is attached to agronomy [1]. But a large number of farmers are losing their lives due to failure in production of crops and due to enhancement of inconvenient deficit due to immense failure of production of crops. The traditional and unscientific approaches to agricultural procedures are the main reason for failure of crop production. Different manual- based methodologies are also used for production of crops and these methodologies are also responsible for failure in production of crops. Machine intelligence has been developed for observing the growth of crops to resolve the above-mentioned problems. The researchers [1] have developed a new machine intelligent system at recording images of growing crops in a particular time. The system consists of a flying drone fitted with a camera eye. For leading agriculturists, this knowledge base machine intelligent system which includes various types of crops and decisions based on crop image analysis has been developed. The amount of green in leaf detection, moisture content in the soil, etc. are planned for analysis from captured images with supporting IoTs [1]. The external camera eye fitted on drone cooperated with Raspberry Pi has been used for taking images of the plant. Different kinds of sensor modules through IoT have been attached to this system. For identification of green leaf, an Android studio has been installed and PlantDoctorMaster-debug.apk file is created. This proposed system was used for commercial and practical purposes [1]. The total number of research papers related to IoT in Agronomy has increased from the year 2010 and the authors of the research papers have applied different methods and different technologies. Different scientists from Asia especially from China are continuing the research on IoT in agronomy and food. But IoT has been adopted by non-agricultural scientists on other continents [2].

The authors of most papers have explored machine intelligent systems which are designed using various blueprints and experiments. Observation and surveillance are primarily focused on the assessment part. But the concept of impulse and remote control has not been mentioned in this assessment part. In the domain of agronomy and food crops, IoT has shown its immaturity. Applications of IoT in the domain of agronomy are inconsistent in nature and the scarcity of flawless amalgamation has been observed. Researchers are working in this area of research for getting modern clarification. In the diversity of domain of production of agricultural food products, IoT technologies have been upscaled to ensure the broad usability [2]. A synopsis of recent IoT technologies and the involvement of IoT technologies in the agricultural sector have been provided by the research scholars [3]. The probable value for future farmers and different challenges faced by IoT have been propagated. The authors of the research papers [4] have explained different regional and technological challenges for the purpose of agricultural food production. IoT based large scale pilots (LSPs) were executed for upgradation of the above- mentioned technologies. The execution of IoT in agriculture has been clearly depicted in the research paper [5]. For managing resources and crops IoT is very helpful. It is also used for monitoring crops and fields for quantitative and qualitative improvement. The sensors are used for the measurement of the temperature of the air, soil pH, soil moisture, humidity, the volume of water, etc. The authors have clearly explained the problems faced by cultivators during the period of using traditional methodologies [5]. They have proposed an easy replica for collection of data and knowledge and dispatched the data of the server over the Wi-Fi network and ultimately the server will take different actions depending on the information. The involvement of human beings is very little in maintenance and monitoring the different farms which are based on agronomy after developing the IoT based solutions. The article [6] has described many features of technologies which are involved in the domain of IoT. A number of features for smart agronomy based on IoT have been mentioned by researchers [6]. They have discussed the network technologies for agronomy which is based on IoT. They have also discussed the basic building block of the used network, different network topologies, and protocols. In this context cloud computing and big data analysis for IoT based agronomy have been represented by the authors of this above-mentioned research paper [6]. For managing the agricultural farm, a number of applications which are based on smart phones and sensors along with different regulations and strategies introduced by several countries have been clearly represented [6]. Different categories of IoT equipment, platforms, standards and network solutions have been discussed by the researchers of the article [7].

In India, the sector of agriculture is decreasing gradually and the entire fabrication of the atmosphere is being highly affected. For getting the solution to this problem an e-Agriculture Application [8] has been proposed on the basis of KM Knowledge and different tracking modules. Detailed information is very much required for profit-making decisions throughout the cultivating cycle. A dataflow model based on knowledge has been constructed and this model has connected to the structure of food crops by connecting numerous separated resources. Different information like retail prices and current level of productivity of crops is very much required and it is scattered in different places [8]. This progress of technology has replaced the manual procedures as it is very much friendly with the environment. Nowadays, the entire world has replaced the manual procedure and minimal man power has been engrossed with this. The traditional procedures used by rural cultivators have been replaced by ICT in agronomy sector of India and the authors of the research paper [8] have explained the benefits of the ICT in Indian agronomy. They have explained the concepts of a different number of detectors. These detectors are used as inputs from the centralized repository of information and they are being used for surveillance purposes.

The replica of the methodology is being accomplished by using TI CC3200 Launchpad. This device contains interrelated detector modules along with other mandatory computerized devices. They have prepared relative research between the modern developed system and the traditional current system and this above-mentioned system [8] has utilized water resources efficiently to overcome the cons of traditional approach and labour cost has been reduced.

The safety and confidentiality issues in the area of green IoT based agronomy have been presented by the authors of the research paper [9]. Survey work for an IoT based agricultural research work has been described by the authors and a categorization of the models related a threat against natural IoT based agronomy has been clearly depicted by the authors. A taxonomy and comparative study of technologies used for protection of confidentiality for IoT applications has been clearly described by the authors and they have also clearly explained the procedure of adaption of this technology for eco-efficient IoT based agronomy. The block chain-based solutions along with consensus algorithms that are based on security issues have been analysed by the authors. They have also underlined different challenges for open research areas along with a number of future scopes [9].

The financial system of India directly depends on cultivated crops. As a result, disease detection of crops is very important [10]. Nowadays most of the things in the whole world depend on the automation and every plant depends on automation for its survival. So a system has been developed through which the plants can communicate. The concept of IoT and the role of IoT in the detection of agricultural disease have been introduced in this paper and this advanced technology has been used for enhancing quality of agronomy. A number of features like detection of leaf disease, measurement procedure of humidity, identification of temperature and color etc. have been included, and in this procedure, sensor networks and digital image processing mechanism have been used instead of a manual check. The authors of research paper have introduced Arduino-UNO for controlling all sensors and all the data value obtained from these sensors for detection of leaf disease [11].

From 400 BC the uses of Betel leaves have played an important role in India [12]. People in India used to chew betel leaves along with areca nut since days of yore as this leaf is completely disinfected, a mouth freshener and energizer, and areca nut was considered as stimulant. But the time when these two different boosting materials were first assembled is completely unknown to the researchers. People have changed their chewing habits over time. Mineral lime hydrate, Catechu (Katha) and other flavoring materials and spices were also attached with betel leaves in an encapsulated package. Between 75 AD and 300 AD in different antiquarian books like Ayurveda, Charaka, Sushruta Samhitas, and Kashyapa Bhojanakalpa, it has been observed that people used to chew betel leaves as a mouth freshener. Kings and nobles in India used to chew betel leaves in the 13th century, as recorded by a European traveler named Marco Polo. In many ancient Ayurveda books, the necessity of betel leaves and their medicinal values have been described. For treatment of numerous diseases, the medicinal values of betel leaves have been described in Chinese folk and betel leaves have detoxification, antioxidation, and antimutation properties [12].

The purified version of extract of betel leaves is used for oral hygiene [13]. The authors of the research paper [13] have described antidiabetic, cardiorespiratory, provocative, immunomodulatory, anti-ulcer, hepato-protective, anti-cancer properties of betel leaf extract. The researchers of the article [14] have explained that novel anticancer and cytostatic extracted from betel leaves have been used for treatment of symptoms of corona virus [14].

The main limitation of the cultivation of betel leaves is betel leaf rot throughout the state. Within a week, vine may be attacked by leaf rot and the entire crop is damaged by this leaf rot. As the humidity of the weather is being increased, the leaves are attacked by the virus. The syndromes of the disease progress very quickly after getting infected and glaze of all the vines of betel leaves have been lost and the leaves have become yellowish. As the disease progresses, the leaves are spoiled gradually. Waterlogged spots or patches have been found due to rot on the vines of betel leaves. Rot on the vine of betel roots will make the leafage fade, dehydrated and dry up, even though they have ample water [15].

In this research article, the authors have discussed an algorithm related to analysis and ranking based on a support vector machine, SVM [16-18] which will help the farmers to classify the distorted leaves for betel plants from the fresh leaves. The authors have demonstrated the concept of the proposed algorithm which is based on SVM and will collect different images of leaves and will be able to detect the infected leaves from a fresh one. They have proposed the concept of smart agriculture so that farmers can use this kind of application software for detecting the infected plant and then can make a decision to prevent this plant as well as other plants from insects and to increase production.

A review of the concept of IoT in agronomy for analyzing betel leaves has been depicted in section 2 after the introduction part in section 1. The authors have discussed the concept of smart agronomy as well as the methodologies for converting the agronomy to smart agronomy using IoT in section 2. The classification of images for diseased betel plant leaves from fresh ones using Support Vector Machine (SVM) has been clearly depicted in section 3. This section has also demonstrated the concept of SVM as well as machine learning techniques. The algorithms for classifying the fresh betel leaf images from rotten images have been clearly depicted by the authors in section 3 also. The authors have analyzed the data and result in section 4.

The key objective of future research will be to construct a full system consisting of a trained model and an application for smart mobile devices with capabilities such as showing known diseases in betel leaves, based on photos of betel leaves captured by the mobile phone camera.

2. Integration of IoT and Agronomy for Analysis Betel Leaves

Nowadays Internet of Things (IoT) is very popular and it has been used for smart agronomy. In 1999, this terminology was invented by Kevin Ashton. For IoT each object transmits information when connected to network : Computer devices, mechanical machines, digital machines and objects. IoT is basically a system of connected computing devices, mechanical and digital machines, objects, animals and human beings [16]. Eccentric identifiers (UIDs) are attached to IoTs along with the ability to transfer data over a network. In this case interaction between humans and computers is not required. Actually, for this system, the physical world has been connected to the internet via sensors. RFID (Radio-frequency identification) has been added to this device. Any natural or artificial object is able to convey data over a network after assigning to an Internet Protocol. Heart monitors for human beings, biochip transponders for farm animals, built-in sensors for vehicles for controlling drivers, etc. are examples of IoT. The conventional way of living has been changed to high- tech life style due to use of IoT. A number of research papers have investigated the enhancement of entire technology through IoT. Intelligent cities, intelligent homes, controlling mechanisms for pollution, mechanisms for saving energy, intelligent transportation, and intelligent industries are such kinds of alterations due to IoT [17]. For increment in demand and decrement in production loss have been solved for this smart agronomy [18]. Robots, drones, sensors and different analytical tools along with computer images have been used for monitoring the agricultural farms, scrutinizing and mapping the fields and thus IoT has been integrated with agronomy. For saving time and money this methodology is capable to supply information to cultivators for perceptive farm management [19].

2.1. IoT Is Transforming the Future of Agronomy

The population of the entire world has been growing exponentially as per the UN Food and Agriculture Organization. Within 2050 production of 70% more food is very much required. Agricultural lands have been decreased and finite natural sources like fresh water and arable land have been exhausted. For this reason, the cultivators have faced the problem to produce staple crops. The labour force of agricultural farms has shifting duty and this labour force has been denied work in the farming industry. For reduction of necessity of manual labour IoT has been integrated with agronomy [20]. This above-mentioned solution is very much helpful to reduce the supply demand gap to ensure plentiful of food crops, prosperity and security of the environment. Precision agriculture is basically the way for using IoT technology to produce plentiful food crops and to decrease the running cost by using optimal resources. Specialized equipment, Wi-Fi, software and different internet technology have been combined with this smart agronomy [21].

As per the review of BI Intelligence survey the approbation of IoT devices in agronomy reached to 75 million in 2020. This estimation has grown 20% per annum. It has been estimated that the intelligent agronomy market size would be increased by 2025 and it will reach $15.3 billion. The cultivators are now able to reduce the wastage and increment the productivity of food crops by using smart agronomy based on IoT technologies. They are able to utilize resources like water, electricity, amount of compost etc.

A special system which is called IoT smart farming solutions is being used for observing the food crops with the help of detectors. The fertilization system is being automated by this above-mentioned solution system. Using this system, the cultivators are able to monitor the condition of the field and they can take decisions based on the retrieved data from manual and automated options. It has been depicted by the researchers that smart agronomy is more efficient than conventional methodology [22].

2.2. Agronomy Has Been Transformed into Smart Agronomy by Using IoT

Smart agronomy or smart agriculture is a rising conception. Sensors along with control systems, robotics, autonomous vehicle, autonomous hardware, movement sensors, the lens with push buttons, multifunctional equipment etc. are the primary component of smart agronomy. Data collected by this system can be used for tracking the business condition and also is used for forecasting the future output for better product distribution. Health estimation of food crops, fertilization system, observation of food crops, analysis of soil and field, implanting are various practices related to agronomy and these practices are increased by ground-based and aerial-based drones. Wireless IoT applications are being used for collecting data by the owners of the farms [23]. This information is very useful for avoiding the transmission of the disease as well as decreasing labor costs. For controlling the environment and removing the requirement for manual interference, an intelligent greenhouse has been designed.

The cultivators are able to collect data by sensors for forecasting the production rate of the crops, storage of the food crops, marketing techniques and risk management. The information related to soil, temperature, pressure, rainfall and humidity is also incorporated [24]. Agricultural production is being increased in an economical way by using IoT in agronomy and thus IoT is working as a driving force. The loss of food products has been decreased by this above-mentioned technology. The primary goal of this technology is to send notification to the cultivators to make them aware and the face of the conventional methodology has been turned by using this technology [25]. Nowadays production of food is being more and more complex and overpriced due to immoderate climate, decayed humus, lands with a scarcity of water and collapsing ecosystems. As per the forecasts of various research work there will be more than 9 billion people in 2050 and application of IoT is very significant for entire nation in the whole earth.

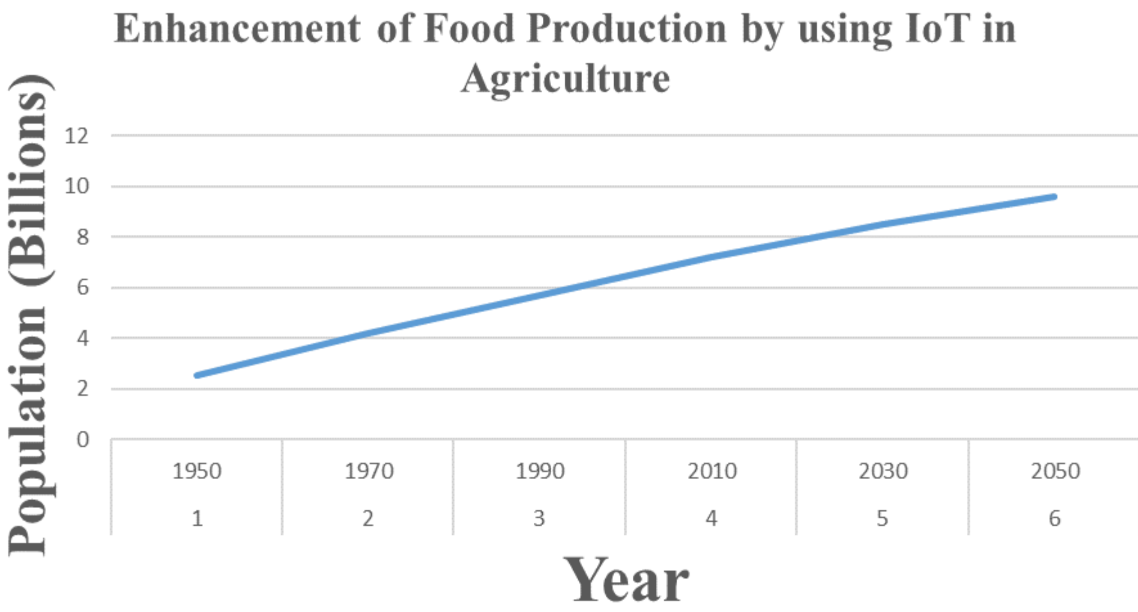

Figure 1. Enhancement of food production by using IoT in agriculture

The researchers have depicted the enhancement of food production by using IoT in agriculture in figure 1. They have collected data for the period 1950 to 2050 and it has been clearly analyzed that using smart agriculture and different updated technologies, the production of food has increased day by day.

2.2.1. Usage of IoT in Building Up Smart Agronomy

Global population is increasing gradually. So enhancement of production of food is very important. But at certain periods disparity in demand and supply is being noticed. For improvement of agricultural production along with plant leaves with medicinal value capital and human resource should be well managed. Smart agronomy with IoT devices with cloud management and a security unit is the better option for improvement of agricultural production. The previous experience of the cultivators is being considered by this device [26-29]. Different challenges and complications are very common issues at the time of integration of modern technology with the traditional approach. So for current smart agronomy, statistical and quantitative approaches are the best revolutionary approach. IoT devices with activated drone are able to monitor the status of the food crop, different stages of irrigation and diseases of foliage in the green natural field. Sensors are taking an active part in this procedure. The authors of the research paper have discussed modern agriculture with IoT devices, a large amount of data and data analytics technology and they are able to evaluate present and immediate future trends in the agriculture sector. For observation of food crops, detector-based systems, humus, fields, domestic animals and for other important factors, detector- based systems are used and ultimately this system is used for enhancement of food production. Automobiles related to smart agronomy, drones, independent machines are connected with this agronomy based on intelligent systems for predictive analysis and planning [30-32].

As betel leaves are the most economical agricultural product, the cultivators are very much concerned about its disease. For detection and identification of unhealthy leaves, image processing methodology is very useful. In the suggested research work, the researchers have clearly explained the three primary phases like initialization, eradication of characteristics and orderly arrangement of phases. For describing the characteristics of betel leaves, the cultivators depend on the texture of the leaves.

3. Support Vector Machine for Classification of Diseased Betel Plant Leaves from Fresh One

In the proposed system for detection and identification of betel leaf status, whether it is fresh or distorted, Support Vector Machine (SVM) algorithm is used for classification phase [33]. A large number of datasets of fresh and distorted betel leaves images were used for both training and testing stages. The authors have defined the concept of machine learning for describing these above-mentioned training and testing phases. Forecasting, recommendations, and estimations are important actions based on historical data for the training phase of the machine learning techniques. Computers behave like human beings by training these data with the help of historical data along with forecasted data [34,35].

3.1. Support Vector Machine (SVM)

A large set of data is forecasted and classified by the mechanism of machine learning algorithms. A special category of supervised machine learning algorithm is the Support Vector Machine (SVM) used for two group analysis and ranking problems. For classification problems, SVM is being used. SVM algorithm is used for plotting every data in n dimensional space. SVM is very useful for performing classification by finding hyper plane and this can clearly differentiate the two classes very well. SVM model works on labelled training data and it is also able to categorize new text [36].

3.1.1. Working Principle of SVM

Two different classes of sets of labelled data provided in the training data are being generalized by SVM which is a special category of machine learning model. For distinction of two classes a hyper plane should be checked and this is the primary goal of SVM [37].

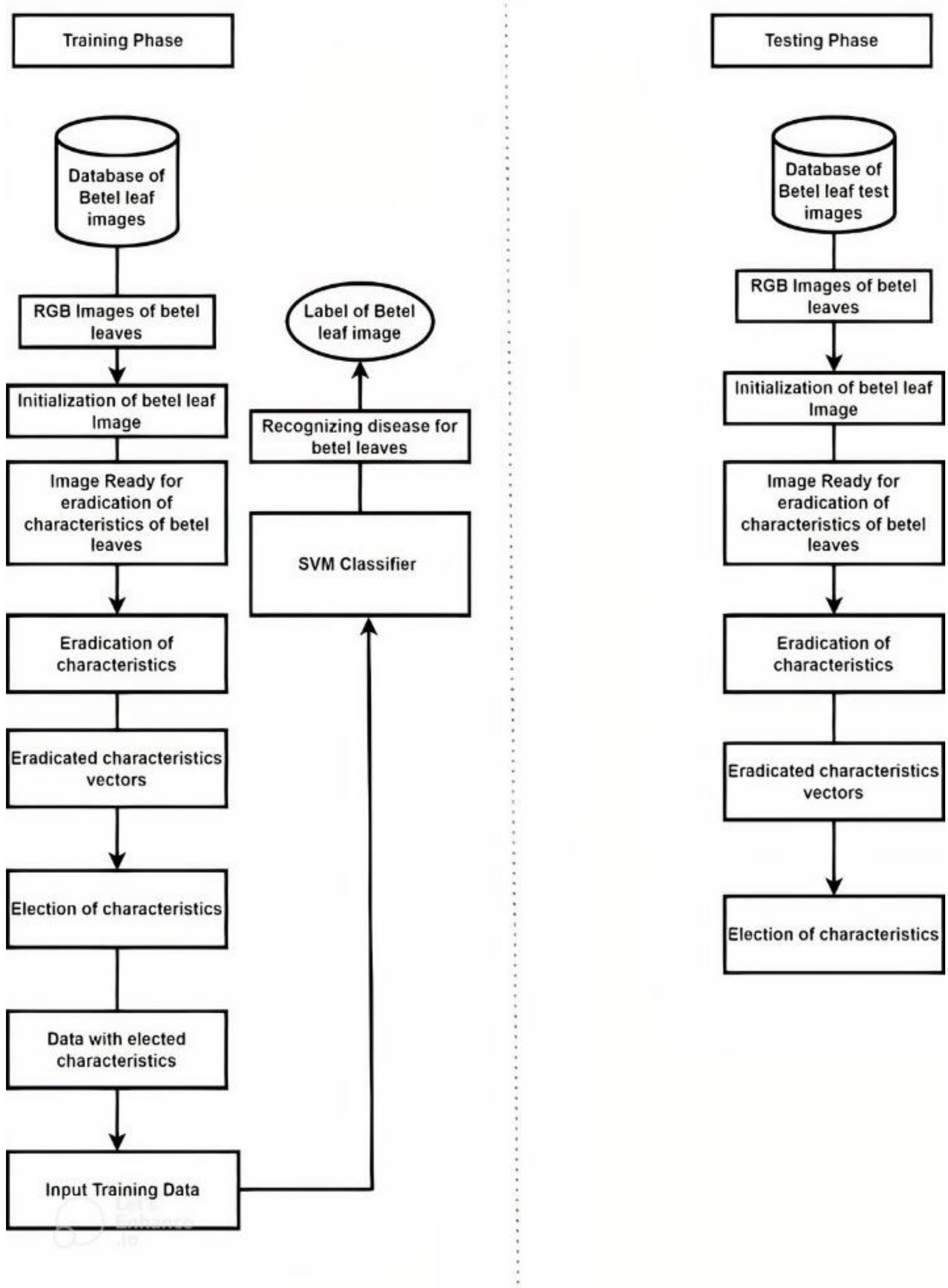

Figure 2. Flowchart of proposed SVM for classification of affected plant leaves

The authors have described the proposed SVM for classification of affected plant leaves in figure 2. They have used the following algorithm for classification of affected plant leaves.

Training Phase:

The initial data used for training machine learning models are called the training dataset. For forecasting or for performing a desired task, machine learning algorithms use this type of dataset [38].

Initialization:

In the pre-processing phase, resizing, thresholding and Gaussian filter have been applied to the image datasets. Resizing method has been applied for changing the original size of the image. Thresholding is used for Image Segmentation and several segments arise inside the image. For reduction of noise and faded region of an image, a filter known as Gaussian Filter is used [38].

Bifurcation (K Means Clustering):

The distorted region of the images of the betel leaves has been detected by K means clustering techniques. Data centre of the image has been derived from K-mean clustering and the clusters of that image have been prepared. Centre distance from the other cluster has been calculated. For extracting general shape information, contour tracing methodology has been performed on digital leaf samples. Characteristics of contour have been analyzed and used for pattern classification after extracting the contour. Determination of efficacy of feature extraction process [38] is very helpful.

Eradication of Characteristics:

After application of segmentation, feature extraction has been applied. New features are being created by existing datasets. Original characteristics have been removed. The number of characteristics in a dataset has been removed by using the process of eradication of characteristics. Most of the information contained in the original set of features [38] is summarized by the new reduced set of features.

After extracting features, a new image database has been formed and this database has been used for testing phase. After application of pre-processing, segmentation and feature extraction methodologies on the tested set of images, SVM classification algorithm has been applied. After that the affected leaves have been classified [38].

Algorithm 1 has depicted the procedure of taking a set of betel leaf images as input data and displaying the entire set of images as output data.

3.2. Algorithms

Algorithm 1:

Step 1: import classifier, module
Step 2: import glob module
Step 3: import pyplot module in matplotlib library and set alias as plt and used for visualization.
Step 4: import image module in matplotlib library and set alias as mpimg
Step 5: import pandas and os module
Step 6: import resize, imread and numpy module
Step 7: Defined Categories=['1','2','3','4']
Step 8: Declared a list named images = [], an input list
Step 9: Declared a list named target_arr=[], an output list
Step 10: Start for loop with img_path in glob.glob(r'D:\Publication\Priyanka work\Project4\Betel leaf*.jpg'):
Step 11: append the element in the list images and the pass the parameters (img_path) in function mpimg.imread() for reading the image.
Step 12: Call a function named figure() through plt for changing the size of figure and provides the figsize attribute that takes two parametrs width 20 and height 10 of a figure in-unit inches
Step 13: set columns = 5
Step 14: Start for i, image in enumerate(images):
Step 15: Call a function named plt.subplot and pass the parameters (int(len(images) / columns +1), columns, i + 1)
Step 16: Call a function named plt.imshow and pass the parameters (image)
Step 17: Call a function named plt.xticks([])
Step 18: Call a function named plt.yticks([])
Step 19: Call a function named plt.show()

The authors have clearly explained the Algorithm 2 for loading all categories of betel leaf images.

Algorithm 2:

Step 1: Start for i in Categories
Step 2: print(f'loading... category: {i}')
Step 3: Start for img in os.listdir(r"D:\Publication\Priyanka work\Project4\Betel leaf"):
Step 4: call imread function and pass the parameters (os.path.join(r"D:\Publication\Priyanka work\Project4\Betel leaf",img)) and returned value will be assigned to array img_array
Step 5: call resize function and pass the parameters (img_array,(150,150,3)) and output is assigned to img_resized
Step 6: append reshaped or flattened images to a python list
Step 7: target_arr.append(Categories.index(i))
Step 8: print(f'loaded category:{i} successfully')

Algorithm 3 has been clearly explained by the author to classify the trained data set along with the test data set. After this classification the algorithm proposed by the authors clearly classified the fresh image of betel leaves with a set of images of rotten betel leaves.

Algorithm 3:

Step 1: import asarray function from numpy module

Step 2: Call asarray function to convert input to an array and pass the parameters (images) and store the output of the function in the variable flat_data

Step 3: print(type(flat_data)) which returns type class

Step 4: printing the number of elements in each dimension of flat_data array by using the shape attribute

Step 5: pass a list target_arr into the array() method and it will be converted into an ndarray target

Step 6: print the type of the target variable

Step 7: display the number of elements in each dimension by using shape attribute of array target

Step 8: to create the DataFrame df from list flat_data

Step 9: print the DataFrame df

Step 10: use x=df.iloc[:,:-1], it selects till the second last column of the data frame as an input data

Step 11: use y=df.iloc[:,-1], it will select the last column as an output data

Step 12: from sklearn import support vector machine classifier

Step 13: import GridSearchCV library function that is a member of model_selection package

Step 14: Assigning the parameters and its values which need to be tuned by using the following statement param_grid={'C':[0.1,1,10,100],'gamma':[0.0001,0.001,0.1,1],'kernel':['rbf','poly']}

Step 15: creating SVC class to compute the probability estimates by setting probability=True

Step 16: GridSearchCV takes an estimator like SVC and parameter grid by using following model=GridSearchCV(svc,param_grid)

Step 17: import the train_test_split function of the sklearn. model_selection package in Python splits arrays or matrices into random subsets for train and test data

Step 18: x, y = np.arange(10).reshape((5, 2)), range(5)

Step 19: In the train_test_split() function, four parameters have been supplied. The first two are for data arrays, while test size specifies the size of the test set by using the following statement x_train,x_test,y_train,y_test←train_test_split(x,y,test_size=0.20,random_state=77)

Step 20: display the message 'Splitted Successfully'

Step 21: from sklearn.svm import SVC

Step 22: Create a SVC classifier using an RBF kernel and auto gamma by using the following statement svc = SVC(kernel='rbf',gamma='auto')

Step 23: Train the classifier by using the fit function and pass the parameters x_train and y_train

Step 24: display the message 'The Model is trained well with the given images'

Step 25: predict the test data by using the trained model

Step 26: display the message "The predicted Data is :"

Step 27: print the value of y_pred

Step 28: display the message "The actual data is:"

Step 29: print the array y_test

Step 30: import accuracy_score method from sklearn.metrics packages

Step 31: Computing and print the accuracy_score of the model. The accuracy score() method of sklearn.metrics accepts as parameters the true labels of the sample and the labels predicted by the model, and calculates the accuracy score as a float number

Step 32: print print the accuracy_score of the model in percentage

Step 33: import classification_report performance evaluation metric from sklearn.metrics of your trained classification model to measure the quality of predictions from a classification algorithm

Step 34: print the Accuracy on unknown data is by using classification_report(y_test,y_pred) function

Step 35: compare some of our predicted values with the actual values and find the accuracy by creating the DataFrame

result = pd.DataFrame({'original' : y_test,'predicted' : y_pred})

Step 36: print the DataFrame result

Step 37: input function is used to take the url of image and assigned to the variable url

Step 38: call the function imread() and pass the parameters(url) and output is assigned to the variable img

Step 39: The imshow() function in pyplot module of matplotlib library is used to display data as an image; i.e. on a 2D regular raster

Step 40: show() function is used to display all figures

4. Data and Result Analysis

Figure 3 shows different images of fresh betel leaves along with affected leaves. The authors of this research paper have applied the above-mentioned proposed algorithm to this image set and were able to classify the images of fresh betel leaves from the affected one. In figure 3, the authors have used ten images of betel leaves. Figure 4 (a)-(e) have depicted the set of images that contain fresh betel leaves whereas figure 5 (a)-(e) have shown the set of images that contain affected diseased betel leaves.

Figure 3. Images of fresh and diseased betel leaves

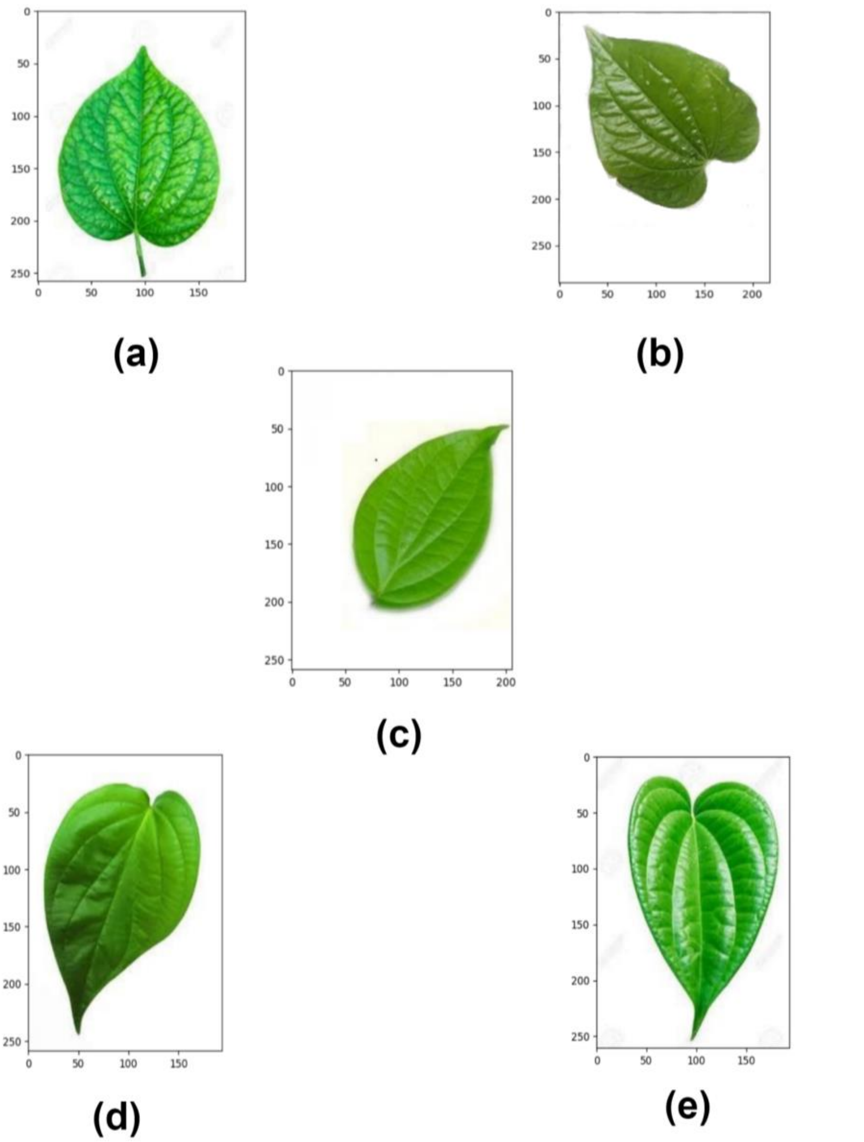

Figure 4. After Classification: Fresh Betel Leaves (a) Type 1 (b) Type 2 (c) Type 3 (d) Type 4 (e) Type 5

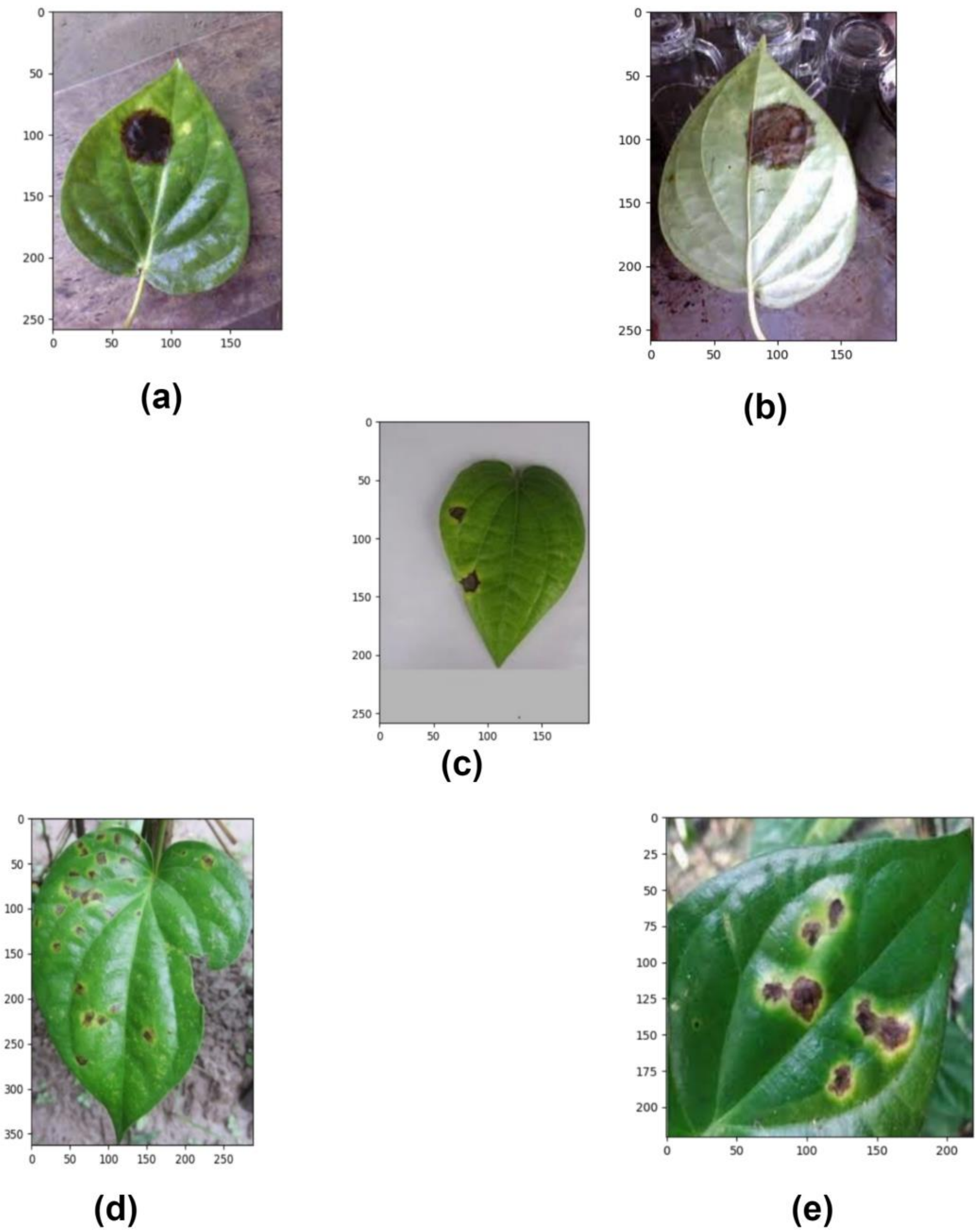

Figure 5. After Classification: affected diseased Betel Leaves (a) Stage 1 (b) Stage 2 (c) Stage 3 (d) Stage 4 (e) Stage 5

5. Conclusions

There are many methods for classification of plant disease detection. A number of researchers are working in this area. But no economic solutions are available on the market. In this research paper a new IoT based approach is being pioneered by the authors. This methodology is highly able to automatically classify and recognize the plant leaves based on different leaf images. Healthy leaves along with distorted leaves have been distinguished by this proposed model. The authors collected different sets of betel leaf images for training purposes, and after that, initialization and segmentation procedures of images have been implemented. Finally, the authors have applied Support Vector Machine (SVM) classification. They have checked the performance of the newly created model. The accuracy of Support Vector Machine (SVM) classifier for classifying this set of fresh betel leaf images with rotten images is about 96%. Internet sources are used for collection of original images and thus a new image database for plant leaves will be created. Enhancement of the database by accumulation of images is the extension of this research study work and this will improve the accuracy of the model. Different procedures of calibration and proliferation will be used to improve the accuracy of the model. The primary objective of the future research work will develop a complete system that consists of a trained model along with an application for smart mobile devices with features such as displaying recognized diseases in betel leaves, based on leaf images captured by the mobile phone camera. This application will serve as an aid to cultivators, enabling fast and efficient recognition of plant diseases and facilitating the decision-making process when it comes to the use of chemical pesticides. Furthermore, future work will involve spreading the usage of the model by training it for plant disease recognition on wider land areas, combining aerial photos of orchards and vineyards captured by drones and convolution neural networks for object detection. By extending this research, the authors hope to achieve a valuable impact on sustainable development, affecting crop quality for future generations.

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