



A Smartphone-based Plant Disease Detection and Treatment Recommendation System using Machine Learning Techniques

Folasade Olubusola Isinkaye

Department of Computer Science, Ekiti State University, Ado-Ekiti, Nigeria

Emmanuel Damilola Erute

Department of Computer Science, Ekiti State University, Ado-Ekiti, Nigeria

ABSTRACT

Plant diseases cause major crop production losses worldwide, and a lot of significant research effort has been directed toward making plant disease identification and treatment procedures more effective. It would be of great benefit to farmers to be able to utilize the current technology in order to leverage the challenges facing agricultural production and hence improve crop production and operation profitability. In this work, we designed and implemented a user-friendly smartphone-based plant disease detection and treatment recommendation system using machine learning (ML) techniques. CNN was used for feature extraction while the ANN and KNN were used to classify the plant diseases; a content-based filtering recommendation algorithm was used to suggest relevant treatments for the detected plant diseases after classification. The result of the implementation shows that the system correctly detected and recommended treatment for plant diseases.

Keywords: Smartphone; Plant diseases; Recommender system; Treatment, Machine learning; Classification.

INTRODUCTION

Agriculture is very important in any nation in the world as it usually provides income and food to a significant fraction of the population. Plant disease, specifically on leaves, has become a source of serious concern in the agricultural sector as it always causes damage to crops and hence a reduction in the quantity and quality of food production. However, speedy discovery and accurate identification of these diseases could assist in developing early treatment approaches while significantly reducing economic loss [1]. Farmers in most developing countries in the world make use of visual inspection techniques for plant disease identification, which could be done either by the farmer or by agricultural experts. This task is extremely tedious, stressful, and time-consuming. Recently, a lot of high-specification smartphones are released which do not only receive and make phone calls, voicemail, and text messages, but also have many different kinds of advanced functionality such as the ability to access the internet, digital media as well as the capability to take high-quality photos. These devices are now essential necessities in our daily life and many people are familiar with how to operate them. The potentials of these devices could be harnessed to resolve most of the agricultural challenges faced by farmers. Many researchers across the world have used modern techniques to increase the detection rate and the accuracy of the results of plant disease. The techniques include machine learning (ML) [2,3] which include artificial neural networks (ANN), decision

trees, support vector machines (SVM), and K-means. Also, deep learning techniques (DL) [4,5] such as convolutional neural networks (CNN) [6].

With the recent advancements in technology, recommender systems (RS) could be integrated with machine learning techniques to assist farmers in making quick decisions on how to combat and control plant diseases that may want to destroy their farm produce. A recommendation system is a promising artificial intelligence (AI) technique that could be used to automatically and speedily generate suggestions of relevant items in the midst of a large number of alternatives [7]. RS has been used to make intelligent recommendations of interesting movies [8], books [9], fashion [10], diets [11] and others to people. In the agricultural sector, RS has also been utilized to recommend fertilizer online to farmers [12], to predict soil fertility and toxicity [13], and to predict suitable nutrients for fertilization of different soil types [14].

Since the rapid development of plant diseases has become a major challenge that is affecting agriculture worldwide, there is also a need for quick intervention to detect, monitor, and recommend effective treatment to optimize production and minimize losses. This study presents a user-friendly mobile-based system for the identification of plant diseases and treatment recommendations using machine learning algorithms.

RELATED WORKS

It is a common knowledge that plant diseases cause major crop production losses worldwide and a lot of significant research effort has been directed to make plant disease identification and treatment procedures more effective [15]. Many factors contributed to this problem such as change in weather condition, evolution of pathogen and vector as well as increase in human mobility [16]. Some of the common diseases that mostly affect plant include aster yellows, bacterial wilt, blight, rice bacterial blight, canker, crown gall, rot, basal rot and scab [17]. Current works that address the identification and classification of plant diseases using diverse ML and DL techniques are presented in the following section.

Sujatha et al. [18] observed ML and DL techniques have been successfully utilized by different researchers to detected different plant diseases. In their work, they tried to compare the performance of support vector machine, random forest, stochastic gradient descent and DL to identify a disease in citrus plant. They reported notable classification accuracy in their experimentation. ML techniques like Naive Bayes (NB), Decision Tree (DT), K-Nearest Neighbor (KNN), Support Vector Machine (SVM), and Random Forest (RF) were used by Panigrahi et al. [19] for detecting maize plant disease. The result of their experiment showed that RF algorithm result has the highest accuracy. According to Karadağ et al. [20], developing a computer-based system would greatly guarantee successful health screening in plant and help reduce the damage caused to plants by these diseases. In their study, they were able to detect healthy and fusarium diseased peppers from the reflections obtained from the pepper leaves with the aid of spectroradiometer. Artificial Neural Networks (ANN), Naive Bayes (NB) and K-nearest Neighbor (KNN) were used for classification. Their overall results showed that leaf reflections can be successfully used with ML for disease detection. Jaisakthi et al. [21] proposed an automatic system for detecting the diseases in the grape vines different machine learning techniques such as Support Vector Machine (SVM), adaboost and Random Forest tree. SVM, according to them gave a better accuracy of 93%. Sardogan et al. [22] establish the fact that if plant diseases are detected early enough, automatic classification techniques will assist in

taking immediate action to curb the disease. They presented a Convolutional Neural Network (CNN) model and Learning Vector Quantization (LVQ) algorithm based techniques for detecting and classifying tomato leaf disease. Arora and Agrawal [23].in their own study proposed the use of Deep Forest algorithm for the automatic recognition and classification of maize plant diseases. They claimed that their technique performed better than Deep Neural models and other traditional machine learning algorithms in terms of performance accuracy. Zhang et al. [24] designed a 13-layer convolutional neural network to learn some advanced features in fruit images using data augmentation techniques and stochastic gradient descent with momentum. 94.94% classification accuracy was reported in their experiment-

This study presents a user-friendly mobile-based system for the identification of plant diseases using CNN, KNN, and ANN models, while a content-based filtering algorithm was used to suggest relevant treatments for the detected plant diseases.

PROPOSED PLANT DISEASE DETECTION AND RECOMMENDATION SYSTEM

This section describes the detailed operation of the proposed model for the detection and treatment recommendation of plant diseases. The proposed model has different components, as seen in Figure 1.

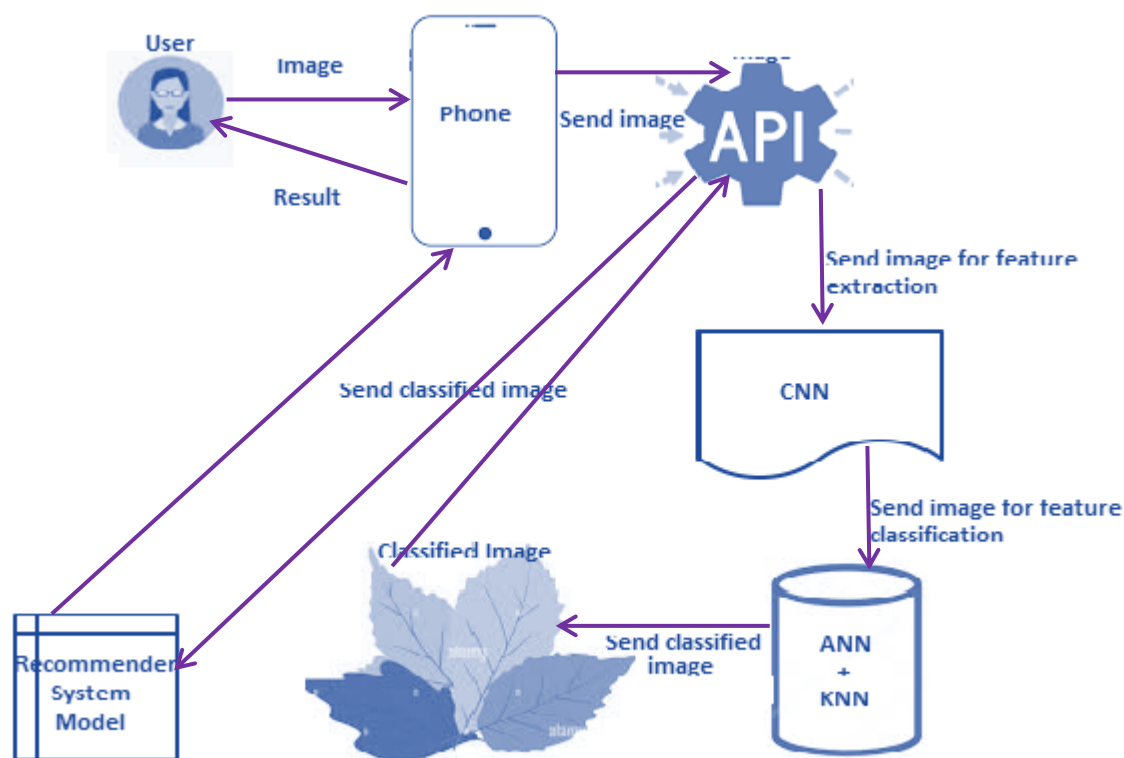


Figure 1: The Proposed System

The system is a mobile application that allows users to input images through the phone camera or select an image from their gallery. Once the image is selected or captured, it is sent to the application programming interface (API). The API directs the image to the convolutional neural network (CNN) where feature extraction for the plant takes place, CNN is used for feature

extraction and not for classification in this work. The K-nearest neighbor (KNN) and artificial neural network (ANN) classifiers are used to train the features extracted from the dataset by the convolution neural network (CNN). The dataset for training and testing was obtained from Kaggle, which is found in the Plant Village dataset at (<https://www.kaggle.com/emmarex/plantdisease>). It contains images of plant leaves with labels showing the names of diseases the plants have. Once the classifiers are trained, predictions can be made. The predictions made by the two (ANN and KNN) classifiers are averaged to get the actual prediction, which then determines the type of disease in the specific plant. Finally, to recommend treatment for the plant disease identified, the plant is sent to the recommendation module. The module consists of different plant diseases, with details of each treatment attached to the disease name. Once the system predicts the plant disease name of an image, the name is sent to the recommendation model, which first converts the name into a vector and then retrieves the file that contains the disease name and treatment. The system converts both the disease name and treatment into vectors and then uses cosine similarity to compare each vector of each treatment with the vector of the disease name sent. The top 5 treatments whose distance is close to the vector of the disease name sent are selected and recommended to the user as the treatment. The algorithm for the system is described as follows in Table 1.

Table 1. Algorithm for the proposed system

System Algorithm
Step 1: The system obtains an image from camera or gallery.
Step 2: This digital image is processed to remove noise.
Step 3: The brightness and the contrast of the image are adjusted so that the image can be easily recognized
Step 4: CNN is applied to extract important features of the image, also edge detection and normalization operations are performed.
Step 6: The features extracted from CNN are passed into the trained ANN and KNN module to make prediction of which disease is in the image.
Step 7: The prediction from each of the model is averaged and then the system selects the disease name.
Step 8: Send detected disease to the Recommender system module.
Step 9: Recommends top 5 treatment for the identified disease.
Stop

IMPLEMENTATION RESULTS

The proposed system was built using different technologies, which include JavaScript Object Notation (JSON), to create the application programming interface (API). Python was used as the programming language to implement the machine learning component of the system; firebase provided the backend for the system database. Flutter was used to design the user interface for the system. The results of the implementation of the system are described as follows: Figure 2(a) depicts the page that serves as the starting point for the plant disease detection and treatment recommendation system. This major screen of the system is known as the *home screen*. It is the part where every activity begins on the system, such as launching the system. Figure 2(b) is the page that allows the user to take a picture of a plant or pick the image of the plant that the user wants to analyze from the phone gallery. Figure 2(c) shows the image selected for disease identification.

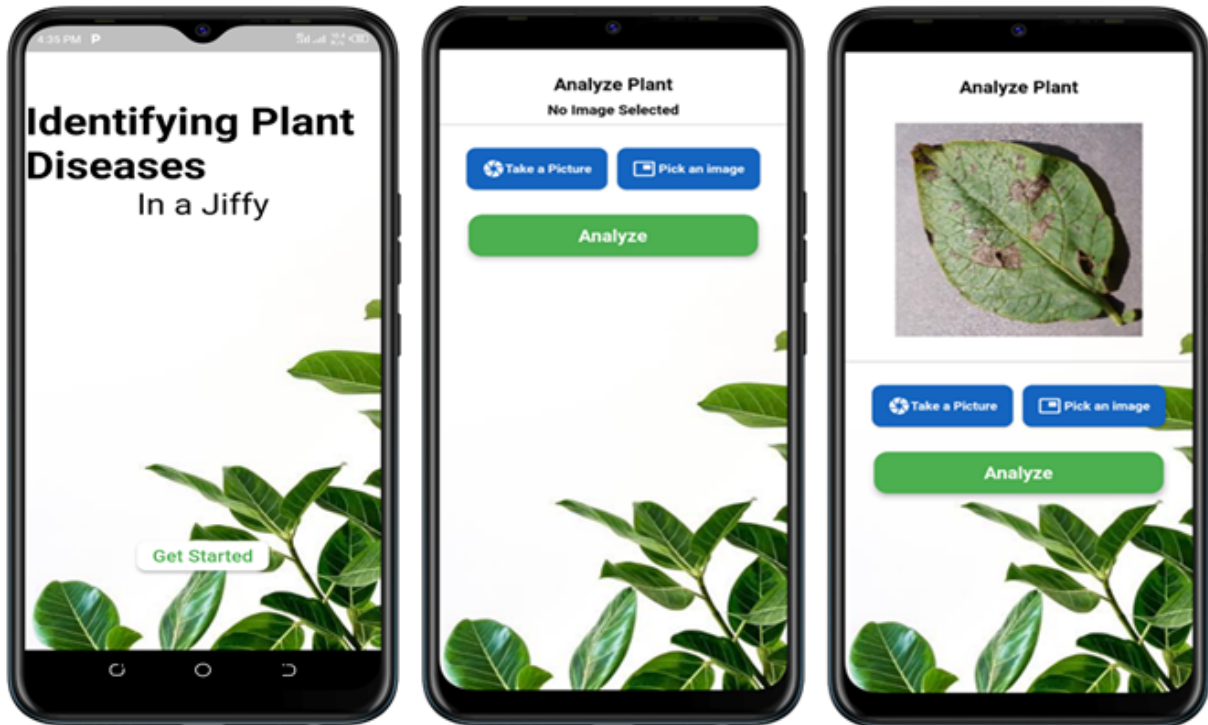


Figure 2: (a): Home Screen

(b): Image Selection Process

(c): The View of Image Selected

Figure 3 depicts the screen where the image sent to the system by the user is being processed in order to diagnose the actual disease associated the plant selected plant image

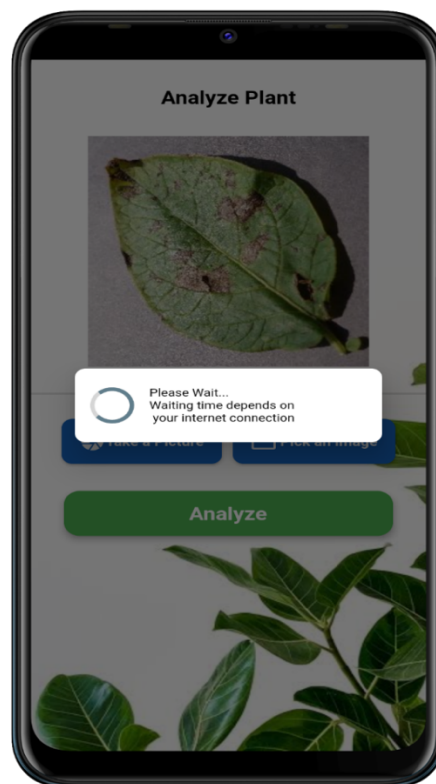


Figure 3: Image selected under processing

Figure 4 shows the output of the processed image. The name of the disease detected and treatment recommendations made. In this case, tomato early blight was detected and the treatments recommended are seen on the screen.

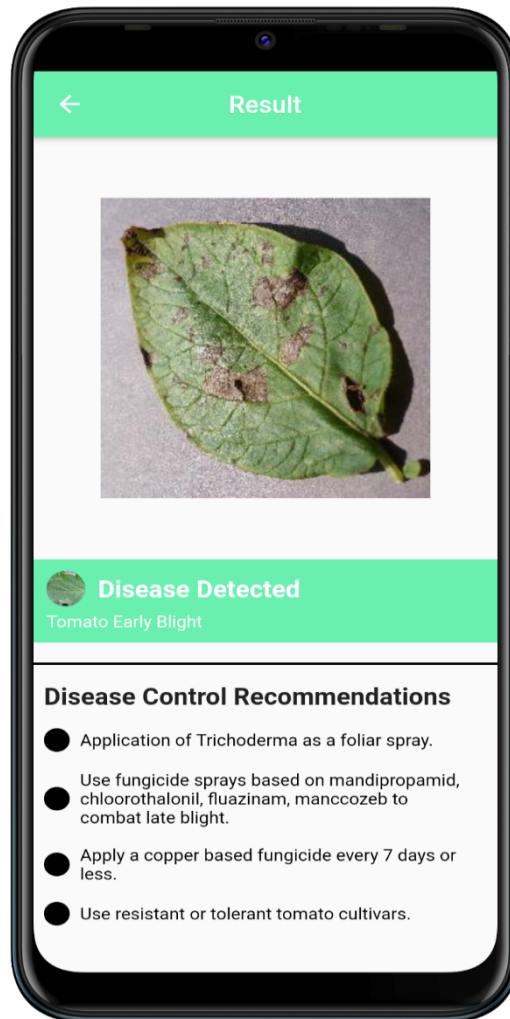


Figure 4: Result of the processed image

CONCLUSION

Early disease identification in plants is very important to avert damages to agricultural yields. Disease identification is a crucial assignment for every farmer as it is practically challenging to manually detect plant diseases by examination and observation through visual inspection. Also, without accurate diagnosis of plant diseases, a lot of resources could be wasted trying to put in place disease control measures. Recently, a lot of researchers have been inspired by the potentials of artificial intelligence and machine learning models to speedily detect plant diseases. In this work, we designed and implemented a user-friendly smartphone-based plant disease detection and treatment recommendation system using ML Techniques. CNN was used for feature extraction while the ANN and KNN were used to learn the plant diseases from the datasets collected from Kaggle. The system was trained to appropriately classify the disease of new plants presented as an input by the user either through the phone camera or gallery. The system was able to recommend treatment for the classified disease using content-based filtering recommender system technique.

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