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IoT Based Solution for Grape Disease Prediction Using Convolutional Neural Networkand Farm Monitoring

R. Chavan[1], A. Deoghare[2], R. Dugar [3], P. Karad [4]

[1, 2, 3, 4] Department of Computer Engineering, Sinhgad College of Engineering, Pune, India.

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Abstract:

Diseases in fruit cause devastating problem in economic losses and production in agricultural industry worldwide.Subsequently, reduction in plant diseases by early diagnosis results in substantial improvement in quality of the product.A solution for predicting the grapes disease is provided, and also detection of the grape disease will be done using CNN approach and real time collected data of environmental parameters are used for predicting the disease probability. The CNN approach is applied on the image of the leaf. Different layers of CNN approach are applied on the image. Training data and testing data are resized into a specific resolution and then provided to the layers of CNN. On the other hand, the values received from humidity, temperature and soil moisture sensor respectively are transmitted to the Microsoft's Azure Cloud by Raspberry-Pi. Then the sensor values are used in a trained Linear Regression model to forecast the percentage of disease. Based on the outcomes of above detection and prediction phases, suggestions of appropriate fertilizers with their appropriate quantity will be provided to avoid excess use of fertilizers and reduce their cost.

Keywords-IoT, CNN, PDI.

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I. INTRODUCTION

Agriculture has been practiced since centuries. Also, much of the economic growth of India depends on agriculture. In many regions of India, most of the farmers practice very obsolete farming techniques. Plant disease is one of the crucial causes that reduces quantity and degrades quality of the agricultural products. Ensuring high crop production yield is critical in maintaining global food security. Prediction and Detection of disease play a major role in the field of Agriculture.

Grape cultivation: Viticulture is one of the most remunerative farming enterprises in India [1]. Grapes originated in Western Asia and Europe. Fruit is eaten fresh or made into juice, fermented to wines and brandy and dried into raisins [1]. Grapes also have medicinal properties to cure many diseases.Grapes are most important fruit crop of the world and is fairly a good source of minerals, vitamins, etc. Maharashtra accounts for 70 % of India's total grape production. Varieties grown include Thompson Seedless, Sonaka, Sharad Seedless and Tas-e-Ganesh. Harvesting lasts from early February to early April.Main diseases causing damages to grape crops are Downy Mildew, Black Rotand Powdery Mildew.Grapes are grown in India in variety of climates and soils, with more than 80 percent of the area falling within the tropical climatic belt. India has the distinction of achieving the highest productivity of grapes in the world. Grape suffers from huge crop losses on account of black rot, esca black measles, leaf blight, downy mildew, powdery mildew and anthracnose [1]. According to the survey of United States Department of Agriculture, annual production of grapes in India was 1,006,000 MT in 2010 and is decreased to 1,000,000 in 2011 with 0.6 % reduction.

The prediction of plant diseases has emerged as a well-established component of epidemiology that is rapidly being incorporated into disease management. The mathematics of the disease progress has matured to a point of becoming a powerful and respected component in the management and prediction of epidemics [2]. This would be especially valuable for disease management if models would eliminate unnecessary pesticide applications and reduce production costs. Traditionally, plant disease models have used Leaf Wetness Duration combined with temperature, to predict infection and colonization, and then identify the risks of epidemic [3]. These types of models have been used with observed climate records to track the favourable periods, indicating tactics or strategies of control [4] [5].

The detection of grape disease also plays an important role in determining the amount of loss caused by disease and avoid any further loss. The Convolutional Neural Network approach is one of the best suited way to detect the percentage of damage caused to grapes quality. CNN is implemented in python using the Keras library. Keras consist of the different models and layers of the CNN such as Convolutional layer, max pooling, etc.

II. Related Work

IIT Bombay implemented system to detect downy mildew based on weather information. They apply a semi empirical model to weather data and find the probability of disease.

"A Neural Network approach for Disease Forecasting in Grapes using Weather Parameters", by S. Sannakki, V.S. Rajpurohit, F. Sumira and H.Venkatesh, provides a system uses Meteorological parameters such as temperature, rainfall and humidity are important for agricultural systems. The proposed system predicts the weather using a modified k-Nearest Neighbour (NN), and Feed Forward Neural Network, and then use above parameters predict the disease outbreaks in grapes.

III. System Architecture

System architecture is divided into three different layers sense, analyse & predict, act as shown in figure Fig. 1. Purpose of sensing layer is to sense all the meteorological parameters; hence this layer involves all the sensors. Also, the sample image of the suspected host will be given as an input by the user.

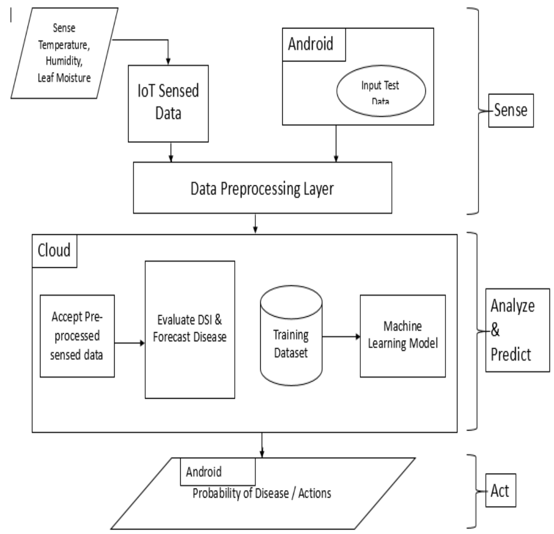

Fig 1: System Architecture

Before analyse & predict layer there exists a layer for data pre-processing. This layer will transform the inputs into a required standard format. Data pre-processing will consist of tasks such as feature selection, data cleaning, handle out of range values and missing values.

Next layer is analyse & predict layer, this layer includes a trained model of for predicting the probability of occurrence of disease. The model is trained using a dataset of image samples of each disease. The output of this layer will be a probability of disease occurrence.

Execution of this layer will be performed on Microsoft's Azure Cloud. Use of Azure cloud services is preferred to enable the mobility of the system on field.

The next layer in the system is act which accepts the output of analyse and predict layer as an input and it acts according to the probability of disease occurrence.

IV. METHODOLOGY

A. Disease Detection (Convolutional Neural Network)

An image of suspected leaf is captured by farmer through his android smartphone's camera and he will upload this image on the cloud using flask web server. And this image will be pre-processed before giving it as an input to detection algorithm.Once the image is pre-processed it can be further used for disease detection. But before using the image for disease detection, it is important to identify that input given by the farmer is a leaf and not something else. To avoid such wrong input, we also have an object detection algorithm which checks the input image and if the input is correctly classified as leaf then the system accepts the leaf image and takes the image to further stage of disease detection.

Using Convolutional Neural Network (CNN) approach, the detection algorithm will classify the image into the most suitable disease type among mentioned three diseases classes Leaf Blight, Esca-black measles and Black rot. CNN consists of different steps i.e. Convolution layer, Activation layer and Max-pooling.

Algorithm for Disease Detection:

Step 1: Farmer log into the system through mobile application.

Step 2: The suspected leaf's image will be given by the farmer for disease detection.

Step 3: To accept only the correct leaf's image object detection algorithm will classify the image into correct or incorrect input image. If the input is leaf, then image will be accepted.

Step 4: Now the leaf image will be resized before passing it for disease detection.

Step 5: The pre-trained model of disease detection stored on the Azure Cloud will be prickled and used for classifying the input image.

Step 6: The output by detection model will be provided to the farmer.

Step 7: Detection model's output will also be stored in Azure SQL Database and provided as detection history to farmer.

B. Forecasting Disease Model

The purpose of prediction model is to forecast a disease.Forecasting of disease depends on the factors in disease triangle i.e. Pathogen, Environmental parameters and Susceptible host.In grapes, probability of disease is high at the time of pruning. Pruning is the process of removing the unwanted branches of the crop.Pruning time for grapes are of two types Backward Pruning and Forward Pruning.

Backward Pruning is carried out between Marchs to May and on the other hand Forward Pruning is carried out in the months of September to November. Hence there are two different models for each disease based on two different time. Models for Downy mildew, Anthracnose, Powdery Germination and Powdery Penetration rate are developed for both the pruning times.

Backward Pruning Model(Downy Mildew)

- Following equation is used to design a Backward Pruning model:

$$Y = 1.7X3 - 3.7X1 + 4.9X5$$

  - Y = Average PDI
  - X_1 = Maximum Temperature(^oC)
  - X_3 = Relative Humidity 7.30hrs (%)
  - X_5 = Evaporation (mm)

- This is a regression model. Above equation uses of 3 environmental parameters. The result of above equation is found to be 93.7% incidence of downy mildew.

Forward Pruning Model(Downy Mildew)

- Following equation is used to design a Forward Pruning model:

$$Y = 2.18X2 + 0.4X3 + 1.2X4$$

  - Y = Average PDI
  - X_2 = Minimum Temperature(°C)
  - X_3 = Relative Humidity 7.30hrs (%)
  - X_4 = Relative Humidity
- This is a regression model.Above equation uses of 3 environmental parameters.The result of above equation is found to be 88% incidence of downy mildew.

Disease Forecasting Model for Anthracnose

- The regression equation for the prediction of severity of anthracnose:

$$Y = 32.00 + 3.30X1 + 0.77X3 - 0.65X4 + 0.20X5$$

  - Y = Average PDI
  - X_1 = Maximum Temperature(°C)
  - X_3 = Relative Humidity (7.30 hrs.)
  - X_4 = Relative Humidity (1.30 hrs.)
  - X5 = Cumulative Rainfall (mm)
- Above equation uses of 4 environmental parameters.The result of above equation is found to be 85% of R^2 values.

Disease Forecasting Model for Powdery Mildew

- The powdery mildew disease depends on two factors for disease germination rate and its penetration rate.
  - **Germination Rate:**

$$GR = -2.641+0.256T-0.00528T^2$$

  - **Penetration Rate:**

$$PR = -0.639+0.108T-0.00254\ T^2$$

Algorithm for Disease Prediction:

Step 1: Farmer logs into the mobile application on his android device.

Step 2: After successful login farmer requests for Prediction of all the diseases.

Step 3: Once farmer requests for Disease Prediction, model for prediction gathers the weather parameters of last 7 days from Weather API and Raspberry PI.

Step 4: By calculating the mean of all the parameters, the mean of these parameters is passed to all the disease prediction models.

Step 5: The output of every individual model will be PDI (Percent Disease Index) of disease.

C. Fertilizer Suggestion

The most crucially important feature of this system is to suggest the Fertilizers to the farmer according to the present status of the farm and appropriate quantity of the fertilizer is provided to avoid side effects caused by over fertilization and reduce cost of fertilizers. Fertilizer Suggestion module uses the PDI calculated by the Disease Prediction module and the pruning date provided by the farmer. If PDI of one or more disease is predicted above 60% the fertilizer suggestion module suggest the fertilizers to farmers.

Initially model takes the input from user i.e. date on which pruning was performed. .The model considers combination of every possible disease and based on the occurrence probability the disease, it is capable of suggesting the pesticides for multiple disease.Finally all the collected results (like fertilizer name, quantity of fertilizers), these results are sent to the users device. Thesesuggestions becomes useful to the farmers to make the fertilizers available in time, so that there is no delay in spraying the fertilizers.

V. ACTIVITY DIAGRAM

Below figure Fig. 2 shows the activity diagram of the working system. As we see, that the system is activities are partitioned into three sections viz. Field, Cloud and User. Activities at field level are the inputs given from the sensors. At cloud level all the processing of the inputs from the user as well as the sensors are processed in order to provide the appropriate output to the user. Finally at user level we could see the suggested fertilizers, disease detected and the probability of all the disease i.e. PDI.

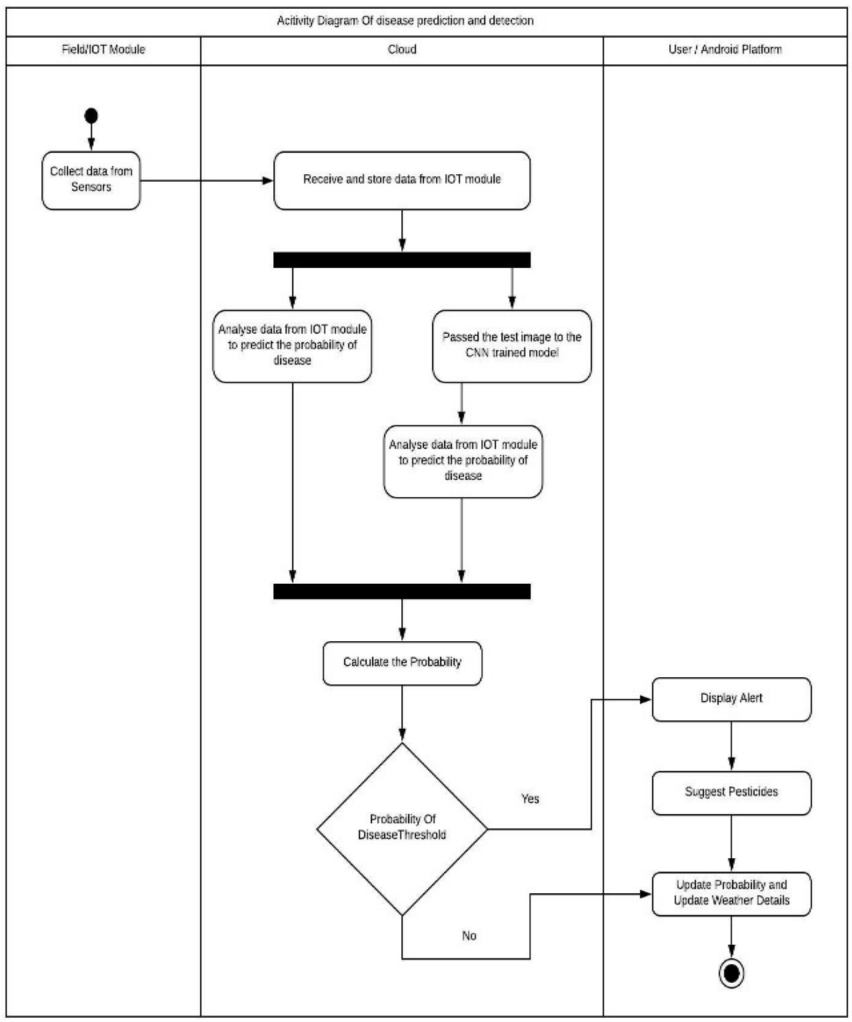

Fig 2: Activity Diagram

VI. RESULTS AND DISCUSSIONS

This Plant Disease Detection and Prediction is totally android based application. It allows to capture images of suspected leaves and detect the type of disease on leaf. The application also allows the user to predict the disease in advance by fetching the historical data from weather APIs and passing that data to the models designed for every disease. This returns the percent disease index. Fertilizer suggestion is also provided so that farmer uses appropriate fertilizers with appropriate amount of fertilizers based on the current status of the farm. This system uses Microsoft azure cloud services hence it requires continuous internet connection to work which makes the application accessible anywhere and at any time. The application is very light as there is no processing present at client side. Following there are some snapshots of our android application.

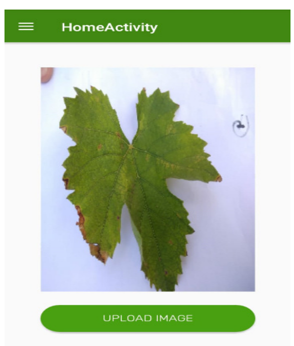

Fig 3(a): Disease Detection

Fig 3(b): Disease Detection

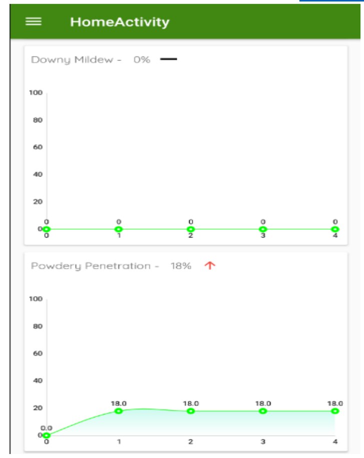

Fig 4: Disease Prediction

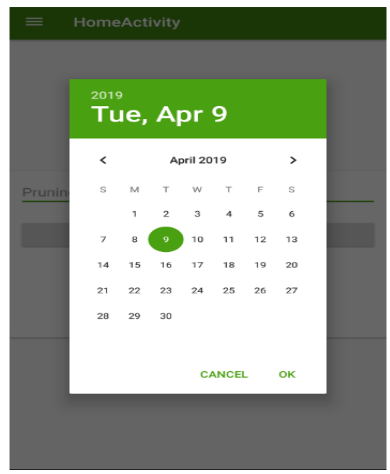

Fig 5(a): Fertilizer Suggestion

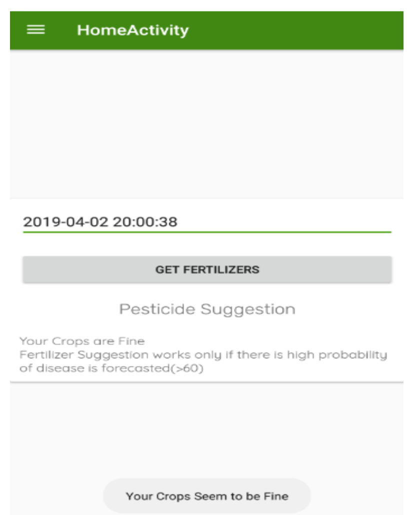

Fig 5(b): Fertilizer Suggestion

VII. CONCLUSION

In this paper, respectively, the application of Convolutional Neural Network have been formulated for classification of disease in grape leaves. Recognizing the disease is main purpose of the proposed approach. Thus, the proposed algorithm was tested on four diseases which had higher influence on production of grapes. These diseases are Esca black measles, anthracnose, leaf blight, black rot. Including disease detection this system also provides disease prediction using the historical weather data. For every disease an individual model is developed which gives the percent chances of the disease to occur on the next day. Finally if the chances of disease are high i.e. greater than 60% then this system also provides the fertilizers with their appropriate quantity. This suggestion of fertilizers is based on the current status of the farm so to avoid unnecessary use of fertilizers and reduce the cost of fertilizers too. So, we have developed a complete Decision Support System for the farmer, which allows him to totally be relaxed and take decisions accordingly. We will dedicate our future to make this system more accurate and reliable for the users.

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