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Disease Detection in Paddy Crop Using CNN Algorithm

Prajwal Raj T D
Undergraduate Student, Department of Electronics and Communication Engineering,
Dayananda Sagar University,
Bangalore, India
praju33td@gmail.com

Vignesh D
Undergraduate Student, Department of Electronics and Communication Engineering,
Dayananda Sagar University,
Bangalore, India
vigneshdev2014@gmail.com

Kushal S
Undergraduate Student, Department of Electronics and Communication Engineering,
Dayananda Sagar University,
Bangalore, India
kushalshanmugha@gmail.com

Shrinidhi M
Undergraduate Student, Department of Electronics and Communication Engineering,
Dayananda Sagar University,
Bangalore, India
shrinidhisamrat@gmail.com

Darshan Halliyavar
Assistant Professor, Department of Electronics and Communication Engineering,
Dayananda Sagar University,
Bangalore, India
darshan-ece@dsu.edu.in

Abstract: In this paper, we propose a technique for detection of the diseases like bacterial leaf blight, brown spot disease and leaf smut in paddy crop using one of the deep learning algorithms called as CNN algorithm. The entire system works on a laptop which acts as processing unit for the proposed system. The well trained Keras model to predict the disease in paddy leaf is developed using CNN algorithm. As the symptoms of the diseases are detected using feature of the paddy leaf, the model is trained using the diseased image data set. The images will be processed by the python script running on the laptop. The trained model will predict the disease using the processed image of the leaf containing the symptoms of the disease. The proposed system also includes the feature which will alert the farmer about spreading of the disease by using the Wi-Fi module to send the message to the farmer of the field through the web application. Also, the pesticides are sprayed by the system to control the further growth of the germs causing the disease. In India paddy is grown as the staple crop. The paddy crop is mostly damaged due to the leaf diseases which are mentioned above. Hence, by implementing this technique, the disease can be detected and loss can be decreased.

Keywords: Arduino Uno, CNN Algorithm, Bacterial Leaf Blight, Brown Spot Disease, Leaf Smut.

I. Introduction

Agriculture is the backbone of any developing country and as such should be paid attention to. Agricultural sector faces various challenges including shortage in farmland, land ownership; economic challenges including globalization, shortage in labour etc., and environmental challenges including climate changes. Agricultural production is expected to double, to meet the food demands, as the world's population is increasing. One of the main reasons of loss in this sector is infection of the crop. In this paper, we present a novel approach to address the problem of infection in the staple food crop paddy. Round the clock monitoring of any large space such as crop fields is a daunting task and cannot be efficiently carried out by human ability alone. Hence, we propose the automation of this task through the proposed system.

Automation is the next phase in industrial growth all over the world. However, in this regard the implementation in the field of agriculture on a large scale has been relatively slow. Agriculture has largely been dependent on the involvement of humans. However, this leaves a lot of responsibility on the farmer for tending to acres of land, exhausting them. Inevitably this in time will lead to some oversight on their part causing losses. Crop infestation is one of the reasons for these losses. Identification of complex diseases that may affect the crop is essential.

The bacterial leaf blight, brown spot and leaf smut diseases will cause physical changes in the leaves of the paddy crop. In this project, deep learning concept is used to detect diseases. Our proposed project includes various phases of implementation namely dataset collection, feature extraction, training the classifier and classification. The collected datasets of diseased leaves are trained using model created using Keras and TensorFlow libraries to classify diseases. For extracting features of an image, we use convolution neural network algorithm. Overall, using deep learning to train the large data sets available publicly gives us a clear way to detect the disease present in plants in a colossal scale. In addition to this, other features such as soil moisture sensing, temperature monitoring, humidity monitoring and pesticides spraying are also implemented in the system using Arduino Uno as the controller.

II. Motivation

Most of the population of India is dependent on agriculture for livelihoods and contributes significantly in the GDP of the nation. Rice is the major staple food of the country and is in every diet in the region. However, rice crop is affected by several diseases that severely damages the yield in a relatively short amount of time. Each year it is estimated that the diseases destroy enough rice to feed more than 60 million people. Since rice is an important food source for much of the world, its effects have a broad range. The diseases have never been eradicated from a region. Bacterial blight of rice has high epidemic potential and is destructive to high-yielding cultivars in both temperate and tropical regions especially in Asia. Found worldwide in temperate and tropical regions, it can destroy up to 80 percent of a crop if the disease develops early. Bacterial leaf blight is a prevalent and destructive disease which affects millions of hectares throughout Asia. Automation is one of the major trends driving innovations in the current industrial revolution. This can play a significant role in the field of agriculture and help increase overall productivity and increase the efficiency at various stages such as cultivation and harvesting. Here we suggest the use of automation and reduce the manual labour of farmer in monitoring their fields.

III. Related Works

The major techniques for detection of plant diseases are:
Back propagation neural network (BPNN), Support Vector Machine (SVM) as seen in the work of Monzurul Islam, Anh Dinh, Khan Wahid, Pankaj Bhowmik [1], K-nearest neighbour (KNN), and Spatial Gray-level Dependence Matrices (SGDM), convolution neural network such as in the work proposed by Yusuke Kawasaki, Hiroyuki Uga, Satoshi Kagiwada and Hitoshi Iyatomi [2]. We have chosen CNN as it is a more accurate and effective method compared to SVM. Endang Suryawati, Rika Sustika, R.SandraYuwana, AgusSubekti, Hilman F. Pardede [3] used the CNN techniques to analyse the healthy and diseased plants leaves. In order to identify the disease affected crops, leaves of crops are collected from the plants and the image processing is performed on the images for extracting features. Then, the deep learning algorithm is used to build the model and leaves are tested with the model for identifying the affected leaf.
In the work proposed by Farhana Tazmim, Nipa Khatun; S.M.Mohidul Islam [4], Content based paddy leaf disease recognition and remedy prediction using support vector machine ,after recognition of paddy leaf disease by support vector machine classifier, the predictive remedy is suggested that can help agriculture related people and organizations to take appropriate actions against these diseases.
Surbhi Jain and Joydip Dhar [5] proposed a generalized project which is used to detect objects using the deep learning concept. In this paper, they confronted an advance deep learning method, Convolutional Neural Network (CNN), for studying feature representations and similarity measures. They explored the applications of CNNs towards solving classification and retrieval problems which has been useful in the development of our work.
Halil Durmus, Ece Olcay Gunes and Murvet Kirci [6] built a robot which is used to detect the disease in tomato plant using deep learning concept. This work aimed at running deep learning algorithm continuously in robot which used to move around fields. The images were captured in real time by using RGB cameras and captured images were used to detect the disease in plants by using deep learning model. Deep learning model has been trained using the tomato leaf dataset provided by Plant village website.
A model which used CNN to identify the disease in tomato and apple leaf was proposed by Rajleen Kaur and Sandeep Singh Kang [7], An enhancement in classifier support vector machine to improve plant disease detection. This model also used Dense layers and sigmoid functions to increases the accuracy of prediction. The overfitting problem has been reduced by using dropout value as 0.2. As a result of these, model achieved 87% of accuracy. As stated earlier CNN algorithm was chosen based on the outcomes of their work which determined the effectiveness of CNN over SVM in predicting correct outcomes.
An approach that integrates image processing and machine learning to allow diagnosing diseases from leaf images was proposed by Mercelin Francis and C. Deisy [8]. This automated method classifies diseases on potato plants from a publicly available plant image database called `Plant Village'. The segmentation approach and utilization of support vector machine demonstrate disease classification over 300 images with an accuracy of 95%.

IV. System Architecture

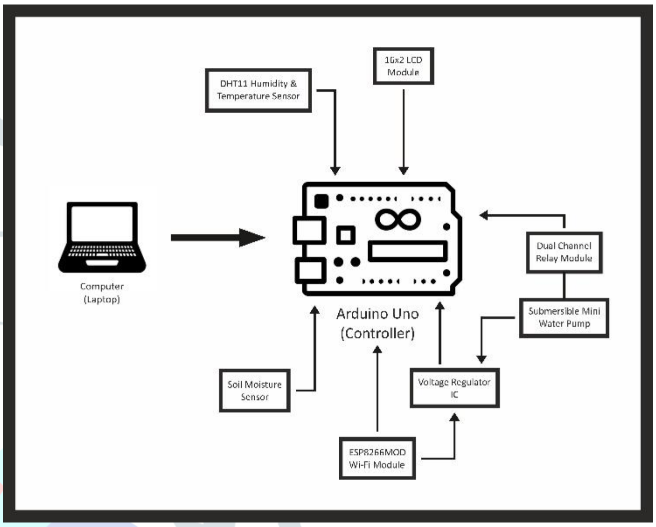


Fig. 1. Block Diagram

The system architecture is as shown in Fig. 1. The images from the real world will be used as the dataset for training the model. The dataset is processed using the commands of Python script which is running on the computer. The trained model will be saved as H5 file (Hierarchical Data Format file) which is trained with the images having the symptoms of the diseases bacterial blight, brown spot and leaf smut. When an image is selected from the test dataset and is given as the input to this model, it will predict which disease is present in that particular image and will also display its accuracy. Then the computer will activate the Wi-Fi module and send the alert message to the farmer’s mobile through the web application.

A. Arduino UNO

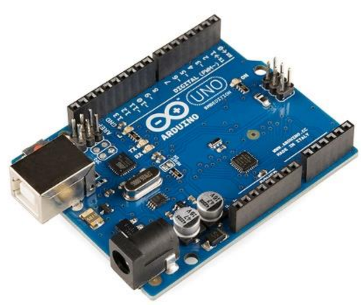


Fig. 2. Arduino UNO

Arduino UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; connect it to a

computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.
The Arduino UNO is used to control all the other components.

B. 16x2 LCD Module

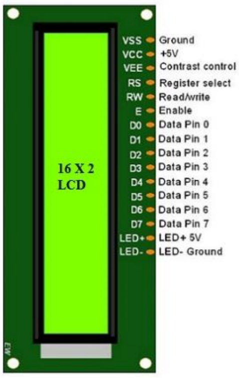


Fig. 3. 16x2 LCD Module

The term LCD stands for liquid crystal display. It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. These displays are mainly preferred for multi-segment light emitting diodes and seven segments. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, special and even animations, etc.
The 16x2 LCD module is used to display the temperature, humidity, pump on or off and the detected disease.

C. ESP8266MOD Wi-Fi Module

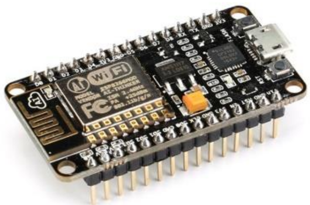


Fig. 4. ESP8266MOD Wi-Fi Module

The ESP8266MOD Wi-Fi module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, it can simply be hooked up to the Arduino device and get about as much Wi-Fi ability as a Wi-Fi Shield offers. The ESP8266 module is an extremely cost-effective board with a huge, and ever growing, community.
The ESP8266MOD Wi-Fi module is used to update messages on the farmer's mobile through the web application.

D. DHT11 Humidity & Temperature Sensor

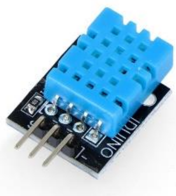


Fig. 5. DHT11 Humidity & Temperature Sensor

DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output. By using the exclusive digital-signal acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost effectiveness.

E. Soil Moisture Sensor

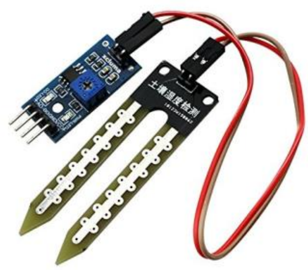


Fig. 6. Soil Moisture Sensor

The soil moisture sensor is one kind of sensor used to gauge the volumetric content of water within the soil. As the straight gravimetric dimension of soil moisture needs eliminating, drying, as well as sample weighting. These sensors measure the volumetric water content not directly with the help of some other rules of soil like dielectric constant, electrical resistance, otherwise interaction with neutrons, and replacement of the moisture content.

F. Dual Channel Relay Module

Fig. 7. Dual Channel Relay Module

A power relay module is an electrical switch that is operated by an electromagnet. The electromagnet is activated by a separate low-power signal from a micro controller. When activated, the electromagnet pulls to either open or close an electrical circuit.
The dual channel relay module is used to operate the mini water pump.

G. Submersible Mini Water Pump

Fig. 8. Submersible Mini Water Pump

This is a low cost, small size submersible pump motor which can be operated from a 3 ~ 6V power supply. It can take up to 120 liters per hour with very low current consumption of 220mA.
The submersible mini water pump is used to spray pesticides and also water, if the soil's moisture content is low.

H. Voltage Regulator IC

Fig. 9. Voltage Regulator IC

A voltage regulator is an integrated circuit (IC) that provides a constant fixed output voltage regardless of a change in the load or input voltage. It can do this many ways depending on the topology of the circuit.

V. IMPLEMENTATION

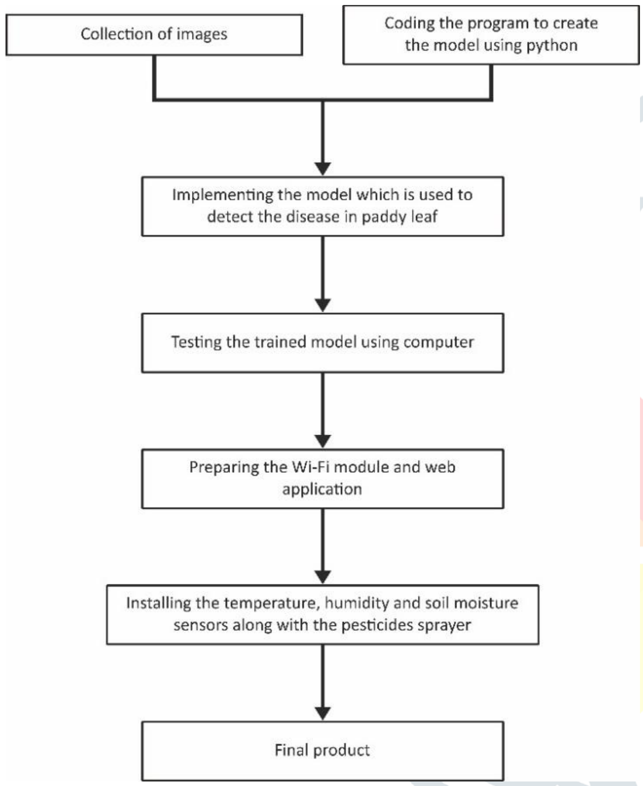


Fig. 10. Flowchart for the proposed system

The flowchart for the proposed system is depicted in Fig. 10. Firstly, the images of diseased leaves are collected for all the three diseases and are used as the dataset to train the model. Then the model is coded using the python programming language. Once the model is trained well with the dataset, an image from the test dataset is selected and the code is run to check if the model is working properly. The test is done using the images from the test dataset and the model displays the detected disease after processing the image. Also, the accuracy of the detected disease is shown.

A. Keras Model

To predict the disease in plants the trained keras model is created using the CNN algorithm. The sequential model consists of many layers. The layers consist of relu activation layer, max_pooling2d layer, conv_2d layer, flatten and dense layer. The layers used is as shown in Fig. 11.

The created model will predict the symptoms of bacterial blight, brown spot and leaf smut diseases in plants. The model is trained using images of these diseases in paddy leaf. The dataset of approximately 500 images for each disease is used to train the model.

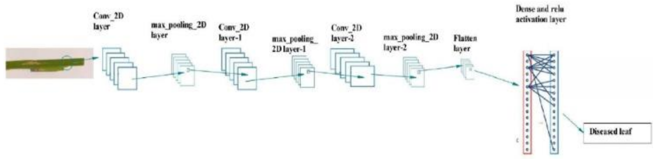


Fig. 11. Details of the layers used in generated model

B. Software Components

➢ Arduino IDE

The Arduino Integrated Development Environment or Arduino Software (IDE) contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.

➢ Adafruit IO

Adafruit IO is a platform designed to display, respond, and interact with project's data. It is basically a web application.

➢ Embedded C

Much like other microcontrollers, the AVR microcontrollers housed in Arduino boards are programmed in a subset of C. A general term for such subsets is "Embedded C" because they apply to programming embedded controllers. Embedded C programming plays a key role in performing specific function by the processor.

➢ TensorFlow

TensorFlow provides a collection of workflows to develop and train models using Python or JavaScript, and to easily deploy in the cloud, on-prem, in the browser, or on-device no matter what language you use. This data API enables you to build complex input pipelines from simple, reusable pieces.

➢ Python

Python is a computer programming language often used to build websites and software, automate tasks, and conduct data analysis. Python is a general-purpose language, meaning it can be used to create a variety of different programs and isn't specialized for any specific problems.

➢ OpenCV

OpenCV is a great tool for image processing and performing computer vision tasks. It is an open-source library that can be used to perform tasks like face detection, objection tracking, landmark detection, and much more. It supports multiple languages including python, java and C++.

➢ PyCharm

PyCharm is a dedicated Python Integrated Development Environment (IDE) providing a wide range of essential tools for Python developers, tightly integrated to create a convenient environment for productive Python, web, and data science development.

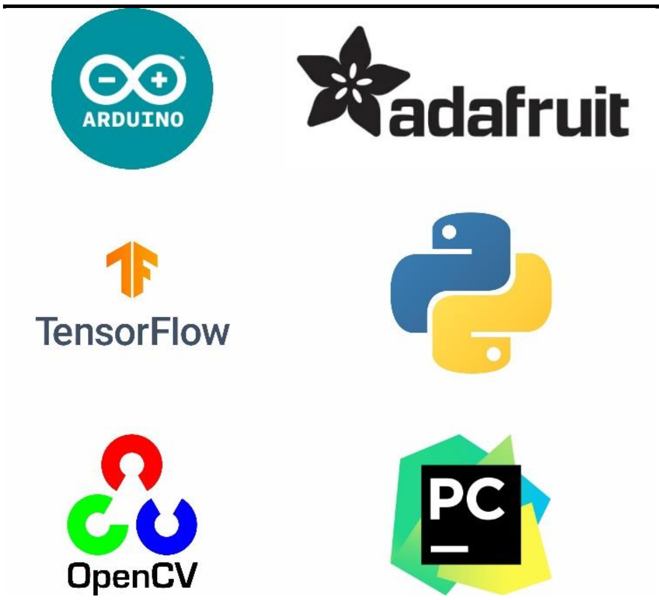
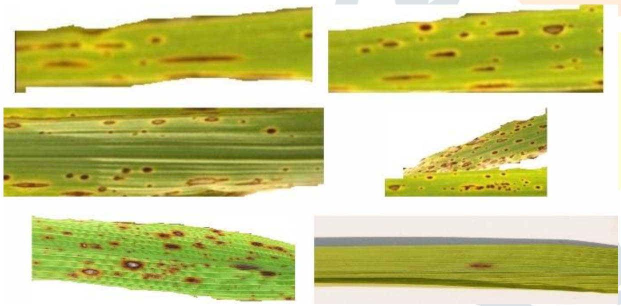


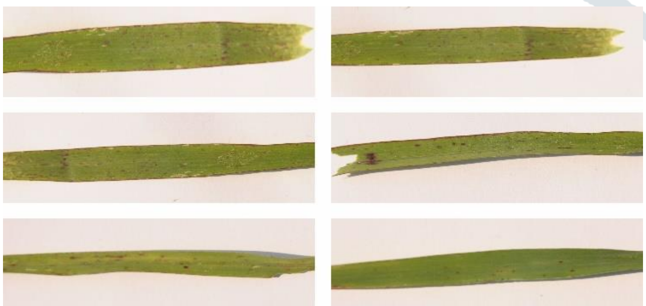
Fig. 12. Software Components

VI. Experimentation and Results

(a)



(b)



(c)

Fig. 13. Sample Images from the Dataset of (a) Bacterial Blight Disease (b) Brown Spot Disease (c) Leaf Smut Disease

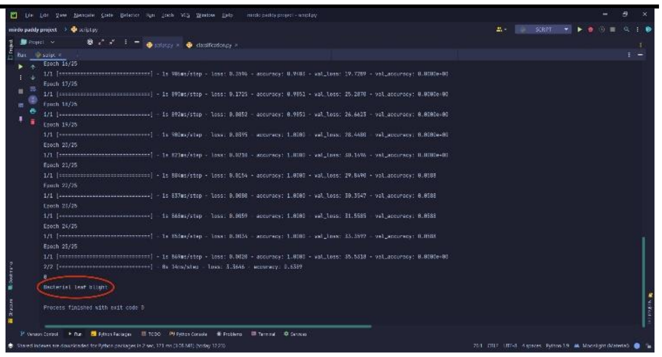
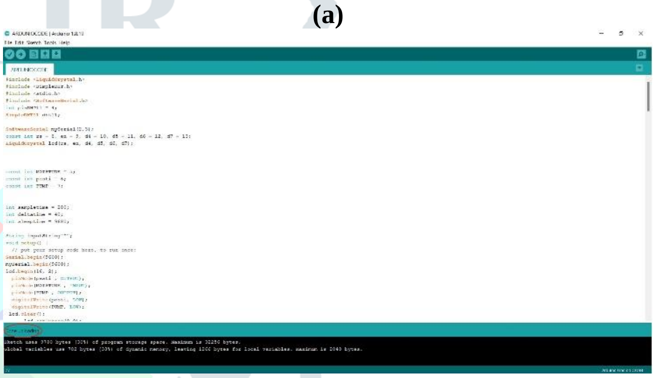


Fig. 14. Results Shown on PyCharm After Executing the Code

(a)



(b)

Fig. 15. Results Shown on Arduino IDE After (a) Compiling the Code (b) Uploading the Code

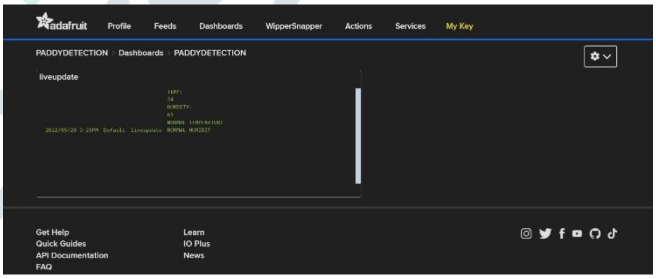


Fig. 16. Web Application (Adafruit IO) Results

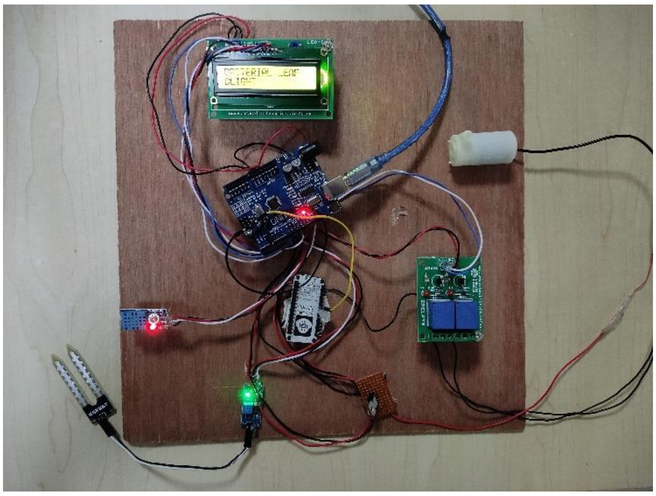


Fig. 17. Hardware Implementation

The experimentation and results of this work is depicted in the figures above which show sample images taken from the pre-defined dataset of each disease, outputs of the codes run on PyCharm & Arduino IDE software and also the messages which are updated on the Adafruit IO web application. The hardware implementation of the block diagram is depicted in Fig. 17. The LCD in the hardware system shows the detected disease as bacterial leaf blight once the serial data 0 is received by the Arduino UNO from the computer. Similarly, if the serial data received by the Arduino UNO from the computer is 1, the LCD shows the detected disease as brown spot disease and if the serial data received by the Arduino UNO from the computer is 2, the LCD shows the detected disease as leaf smut disease. The LCD also shows temperature, humidity and whether the pump is in on or off condition. The accuracy of the detected disease is shown on PyCharm software once the code is executed and this is shown in Fig. 14.

VII. Conclusion and Future Scope

This work presents a technique which detects the diseases like bacterial blight, brown spot and leaf smut using CNN algorithm. The keras model is trained with five hundred images dataset for each disease. The diseased leaf images are processed by python script. The keras model is used to predict the disease in the processed image. Once the disease is detected the alert message is sent to farmer through the web application using the Wi-Fi module. We got the success rate of approximately 85% accuracy.

In the future, Raspberry Pi can be used as a portable computer instead of the laptop and a camera can be used in the system instead of the pre-defined dataset for real-time monitoring of the rice fields. More images can be included in the dataset and the accuracy rate can be increased. Also, accuracy of the images can be improved by using specific filters.

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