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Agni - A Plant Disease Detection Robot

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***Abstract*— Agriculture gives a huge economic growth to our country. With a good yield it also brings disease in crops, which affects the production of food crop. Therefore identifying the type of disease plays a very important role in agriculture. Detection of the various plant disease is the method to prevent the losses in yield quality and quantity. The study of plant disease means the study of visually observed patterns on the plant leaf. To identify the disease, image processing technique is used. Detection of disease can be observed by following steps which come under image processing technique i.e. image acquisition, image pre- processing, image segregation, feature extraction and classification. Further in this project, we aim to build a bot which uses algorithms to study various visually observable patterns on the leaf to detect and classify the disease. Crops such as tomato, potato and chili are considered in the project to detect their respective plant disease. With plant disease detection it will also be programmed to suggest the suitable pesticide to cure the disease of the plant. It will also have pesticide containers on-board, based on the suggested pesticide the spraying mechanism will spray the pesticide on plant.**

Keywords— Image Processing and it's related terms.

I. INTRODUCTION

India is a cultivated country and about 70% of the population depends on agriculture. Farmers have large range of diverseness for selecting various suitable crops for cultivation. And with cultivation of crops it also brings disease on the plant which leads to the significant reduction in both the quality and quantity of agricultural products. The study of plant diseases refers to the study of visually observable patterns on the plants. Monitoring of plant and protecting it from diseases plays an important role in successful cultivation of crops in the farm.

In early days, the monitoring and analysing of plant disease were done manually by an expert person on field. This requires tremendous amount of work and also requires more processing time. So introducing image processing technique in agriculture for the plant disease detection can help to detect the disease and treat it in time. In most of the cases disease symptoms are observed on the leaves, stem and fruit. The plant leaf for the detection of disease is considered as it is easier to study the leaf patterns. The type of plant disease is identified using image processing by taking the leaf image and running through algorithms like CNN. It provides information about the disease which infected the plant.

In this project we are developing a robot which uses CNN to identify and classify plant disease based on the type. With plant disease it is coded to provide the suitable pesticide to treat it. In addition to this a spraying mechanism on-board is used to spray the suitable pesticide on the plant.

Fig.1. Agricultural Field

II. PROBLEM STATEMENT

The major problem which is faced by farmers is "Lack of yield due to crop diseases". Lack of technological advancement and appropriate farming techniques are responsible for the current state of the agriculture sector. The majority of the farmers live in rural India don't know to deal with the diseases of the plants and are unaware of which fertilizer or pesticides to be used. So farmers do not get the desired result, which is a main reason for giving up farming.

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Fig.2. Agricultural Processes

III. OBJECTIVES

The main objective of our project is :

A. Early identification of disease in a plant.

If early identification of disease in a plant is not done then the disease will not only spread in the plant about it will also spread to the nearby plants

Fig.3. Diseased Plant

B. Suggesting and spraying a suitable pesticides for the plant based on the disease.

Based on the identified plant disease the suitable pesticides for plant is suggested and robot will spray the pesticide.

Fig.4. Pesticide Spraying

C. Agriculture field suitable mobility bot/vehicle.

The bot will designed in such a way that it will suitable for moving in the agriculture field.

Fig.5. Path For Bot Mobility

IV. LITERATURE SURVEY

Sunil S…[1] The suggested model employs pre-processing methods such as RGB to grayscale conversion, HE, K-means clustering, and contour tracing. To identify a sick leaf, machine learning techniques like SVM, K-NN, and CNN are applied. The proposed model's analysis works well with the accurate CNN machine learning technique.. Sai Kirthi...[2] This design is intended to be an autonomous agricultural field robot that operates at the microscopic level and offers consumers real-time disease detection and carefully regulated pesticide spraying. R Prakash…[3] Implementation of the leaf disease detection and categorization method. K-Means segmentation is used to separate the sick section into its component parts. After that, GLCM texture characteristics are extracted, and SVM is used to classify the data. B Mishra…[4] Several researchers have employed various methods of plant disease detection utilising image processing in recent years. BPNN, SVM, K-means clustering, Otsu's method, CCM, and SGDM were the main approaches used. V Pooja...[5] The identification of plant diseases using a variety of methodologies is the primary topic of this research. The performance of the system has been improved, leading to better results, by the consistent use of Support Vector Machines as a classifier as well as a variety of methods of feature extraction.

Bandi Narasimha…[6] This paper describes a webcam-based surveillance camera that operates on a Raspberry Pi. Videos can be transmitted over the internet in the same way that photos are. As a result, the camera's coverage area is exceptionally large. Compared to traditional CCTV cameras, drone cameras, and camera traps, it is more advanced. Nithin Vasanth...[7] It talks about an automated spraying system driven by solar energy. Using a DC pump and nozzle, a four-wheeled vehicle is automatically driven along a predetermined course while spraying herbicides. Chaitali G…[8] Plant illness can be identified by looking at designs on leaves, and using an image processing technology, the clicked photo is sent directly to the DSS without any further input. Muhammad Ayaz…[9] The paper concentrates on improved and more effective crop-growing methods. creation of novel techniques to increase

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crop handling and yield. The report took all of these factors into account and emphasised the importance of numerous technologies, particularly IoT. R P Narmadha…[10] Recognizing paddy illnesses is the paper's goal. The method was created to automatically remove noise, reduce human error, and shorten the amount of time needed to measure the effects of paddy leaf disease. This study assesses digital image processing methods for spotting, identifying, and diagnosing crop leaf diseases. For greater accuracy, the k-means clustering technique is employed to automatically detect the disease.

V Gupta…[11] An algorithm is suggested for cherry leaf image-based identification of powdery mildew disease. The suggested technique involves automated strategic background removal from the image before separating the required sick area. The suggested approach is examined using a set of open data from arXiv e-prints. The algorithm under test is 99% accurate. Vijai Singh…[12] By utilising a genetic algorithm for picture segmentation, which automatically recognises and categorises plant diseases, plant disease can be detected in its early stages. Artificial neural networks, Bays classifiers, fuzzy logic, and hybrid algorithms can be used to improve classification in place of the suggested technique. S Abed…[13] By developing an HSI model and utilising K-means clustering segmentation, GLCM is utilised for feature extraction, and SVM is used for image classification, two forms of bean leaf disease are diagnosed with 100% accuracy. Gurleen Kaur …[14] This report basically focuses on the identification of plant diseases using a variety of methodologies. Use of different feature extraction methods and a reliable classifier, Support Vector Machines (SVM), have improved the system's performance and led to better outcomes. Md.Tariqul …[15] the work is on detecting disease on affected plant by using image processing and CNN model for training the database. 94.29% accuracy can be seen in the model.

Mohammed Khalid…[16] leaf disease is detected using machine learning and image processing, GLCM and K-means clustering is used for feature extraction of leaf and by GUI model contrast enhancement of Colour of leaf is done from which SVM classifies the image and give 95.46% of accuracy in detection of leaf disease. S. Nema…[17] The SVM image processing technique is described in the paper together with ideas for prevention in order to detect disease in wheat leaf plants. This image processing method makes it simple to recognise and categorise different plant diseases. An automated system that can make the first announcement of disease can be developed using a processor and the necessary equipment. Vidyashree Kanabur…[18] the paper is made with a reference of a textbook name "Computational Vision And Bio-Inspired Computing" there are different image processing techniques mentioned with its applications. Thanjai Vadivel…[19] The paper focuses on the tomato disease's programmed position with respect to the leaf. To identify tomato diseases and bugs, identification models have been developed utilising learning innovation. The basic decision is based on test photos for relative top indentation. The tomato crop illness is recognised using a CNN-based algorithm. Muhammad Amir…[20] The suggested technique makes use of sensor devices to identify variables like temperature, stickiness, and leaf shade. Ranchers, businessmen, botanists, food designers, and physicians can all use the proposed approach in different regions. S. Kumar…[21] By examining the plant's leaf pattern and using segmentation techniques like k-means clustering to extract different features, different plant illnesses can be detected. Different types of diseases are categorised using the Support Vector Machine (SVM) classifier and the Grey Level Co-occurrence Matrix (GLCM).

V. METHODOLOGY

The following parts are given to explain the methodology of the project:

A. Part 1
1) A bot which moves around the crop field.
2) Captures the images of the plants.

B. Part 2
1) With the aid of machine learning, quick and effective image processing algorithms can be created.
2) The first phase of the algorithms works with separating the healthy crop from the diseased crop, and the second task of the algorithms is focused on identifying the crop disease.

The steps in image processing:
(i) Image acquisition
(ii) Image Pre-processing
(iii) Image segmentation
(iv) Feature extraction
(v) Detection and classification of plant disease

C. Part 3
1) After disease detection, the suitable pesticide will be given.
2) The bot will sprays the pesticide on the diseased plant.

VI. BLOCK DIAGRAM

The block diagram of the project is illustrated in the Figure 6 and Figure 7. The Figure 6 shows the circuit controlled by the Raspberry pi. And the Figure 7 shows the circuit controlled by the Arduino Uno.

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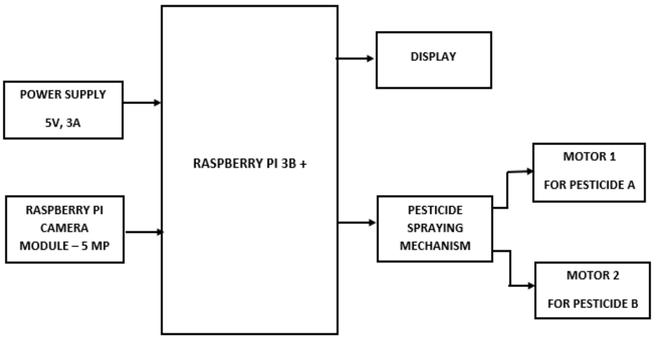

Fig.6. Raspberry Pi Controlled Circuit

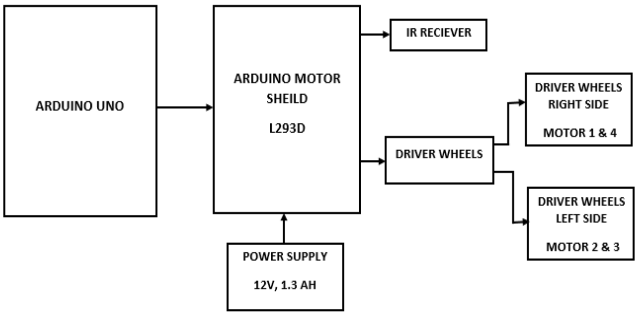

Fig.7. Arduino Uno Controlled Circuit

VII. 3 – DIMENSIONAL REPRESENTATION OF BOT

The 3-Dimensional representation of the robot is shown in the Figure 8.

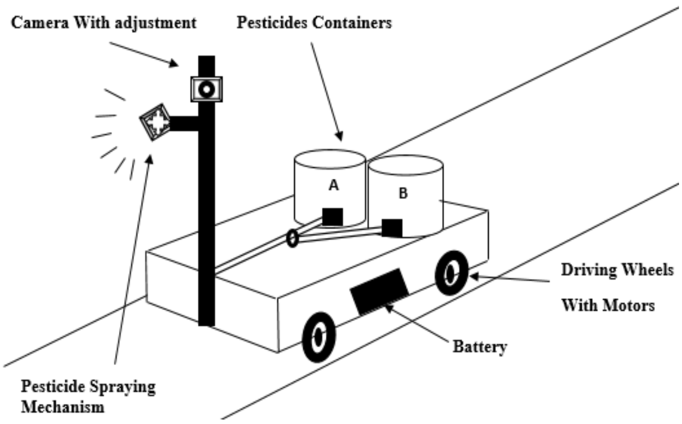

Fig.8. 3-Dimensional Representation Of Bot

VIII. FLOWCHART

The flow of the project is shown in the flowchart in Figure 9.

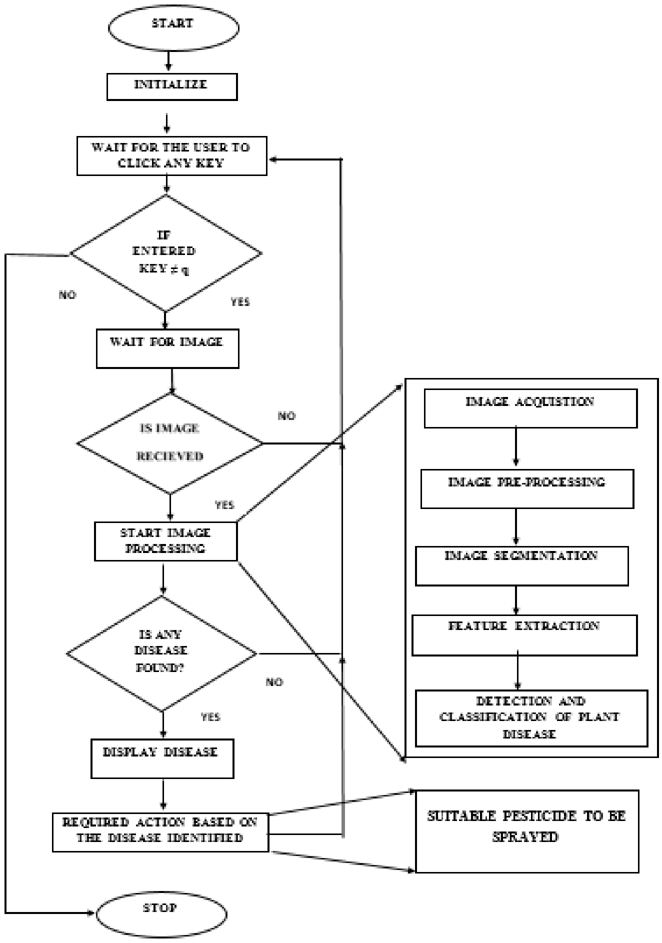

Fig.9. Flowchart

IX. TOOLS USED

A. Tools used for Software Implementation

1) Python
2) Tensorflow
3) OpenCV
4) Google Colab
5) Visual Studios
6) Thonny

B. Tools Used for Hardware Implementation

1) Raspberry Pi 3B +
2) Raspberry Pi Camera V2
3) Arduino Uno
4) L293D Motor Driver
5) Relay – 5V
6) OLED Display
7) CA-2596 DC-DC Buck Converter
8) IR Reciever Module – KY-022
9) Johnson Motor – 60 RPM
10) Robot Wheels
11) Aishang Solar Pump
12) Servo Motor – SG90/MG996R
13) Battery – 12V
14) Bread Board
15) Switches
16) Connecting Wires :
Single Stranded , Multistranded, Jumper Wires

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X. IMPLEMENTATION AND RESULTS

A. Software Implementation

1) Training model

In this section a VGG19 model using transfer learning on a dataset of tomato images gets trained. The dataset is split into training and validation sets, and image data generators are used to perform data augmentation and preprocessing. The model is compiled using the Adam optimizer and categorical cross-entropy loss, and accuracy is used as the evaluation metric. Early stopping and model checkpoint callbacks are used to save the best model based on validation accuracy. Finally, the accuracy of the best model on the validation set is printed. And the result is as shown in figure 10-12.

```
Epoch 6/50
19/19 [==============================] - ETA: 0s - loss: 6.5487 - accuracy: 0.7220
Epoch 6: val_accuracy did not improve from 0.71711
19/19 [==============================] - 14s 726ms/step - loss: 6.5487 - accuracy: 0.7220 - val_loss: 8.4058 - val_accuracy: 0.6678
Epoch 7/50
19/19 [==============================] - ETA: 0s - loss: 5.3455 - accuracy: 0.7467
Epoch 7: val_accuracy did not improve from 0.71711
19/19 [==============================] - 14s 761ms/step - loss: 5.3455 - accuracy: 0.7467 - val_loss: 9.1237 - val_accuracy: 0.6990
Epoch 7: early stopping

[ ] from keras.models import load_model

    model = load_model("/content/best_model_tomato.h5")
    acc = model.evaluate(val)[1]

    print(f"The accuracy of the model = {acc*100} %")

32/32 [==============================] - 7s 195ms/step - loss: 7.1755 - accuracy: 0.7170
The accuracy of the model = 71.70000076293945 %
```

Fig.10. Training Model For Tomato Plant Disease using Dataset

```
Epoch 50/50
19/19 [==============================] - ETA: 0s - loss: 0.1192 - accuracy: 0.9862WARNING:tensorflow:
WARNING:tensorflow:Can save best model only with val_accuracy available, skipping.

[ ] from keras.models import load_model
    model = load_model("/content/best_model_potato.h5")

[ ] acc = model.evaluate(val)[1]
    print(f"The accuracy of the model = {acc*100} %")

10/10 [==============================] - 2s 173ms/step - loss: 2.7180 - accuracy: 0.8567
The accuracy of the model = 85.66666841506958 %
```

Fig.11. Training Model For Potato Plant Diseases Using Dataset

```
Epoch 1: val_accuracy improved from -inf to 0.52000, saving model to best_model_chilli.h5
19/19 [==============================] - 15s 692ms/step - loss: 9.0543 - accuracy: 0.4375 - val_loss: 7.5721 - val_accuracy: 0.5200

[ ] from keras.models import load_model
    model = load_model("/content/best_model_chilli.h5")

[ ] acc = model.evaluate(val)[1]
    print(f"The accuracy of the model = {acc*100} %")

2/2 [==============================] - 1s 142ms/step - loss: 7.5721 - accuracy: 0.5200
The accuracy of the model = 51.99999809265137 %
```

Fig.12. Training Model For Chilli Plant Diseases Using Dataset

2) Plant disease detection – testing- by loading image

In this section the program is a Python script that uses a pre-trained deep learning model to predict the type of disease affecting a potato plant based on an input image. It first loads a trained model saved in an h5 file, then defines a mapping from class index to class name, and a dictionary mapping disease names to recommended pesticides. It then defines a function predict disease that loads and pre-processes an image, uses the trained model to make a prediction on the image, and returns the predicted disease name and the recommended pesticide based on the dictionary mapping. The example usage at the end of the program shows how to call the function with the path to an input image. And its result is as shown in Figure 13-15.

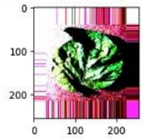
```
path = "/content/tomato/train/Tomato___Septoria_leaf_spot/04840559-16ed-4f17-908b-2048ba83ab80___Keller.St_CG 1780.JPG"

def plot(path,label):
  for im,l in zip(path,label):
    plt.figure(figsize=(2,2))
    plt.imshow(im)
    plt.show()

plot(t_img[:1],label[:1])

prediction(path)

WARNING:matplotlib.image:Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
```




```
1/1 [==============================] - 0s 20ms/step
The image belongs to Tomato___Septoria_leaf_spot and the recommended pesticide is Fungicides like Chlorothalonil, Mancozeb, etc.
```

Fig.13. Testing For Tomato Plant Disease By Loading Image

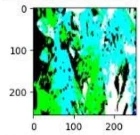
```
path = "/content/Chili_Plant_Disease/train/leaf curl/download (10).jpg"

def plot(path,label):
  for im,l in zip(path,label):
    plt.figure(figsize=(2,2))
    plt.imshow(im)
    plt.show()

plot(t_img[:1],label[:1])

prediction(path)

WARNING:matplotlib.image:Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
```




```
1/1 [==============================] - 0s 21ms/step
The image belongs to leaf curl and the recommended pesticide is Insecticides like Thiamethoxam, Acetamiprid, Imidacloprid, etc.
```

Fig.14. Testing For Chilli Plant Diseases By Loading Image

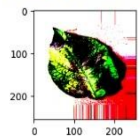
```
path = "/content/Potato/Valid/Potato___Early_blight/93992994-fcb0-4d3e-b528-e6fd9fd1b317___RS_Early.B 6686.JPG"

def plot(path,label):
  for im,l in zip(path,label):
    plt.figure(figsize=(2,2))
    plt.imshow(im)
    plt.show()

plot(t_img[:1],label[:1])

prediction(path)

WARNING:matplotlib.image:Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
```




```
1/1 [==============================] - 1s 709ms/step
The image belongs to Potato___Early_blight and the recommended pesticide is Fungicides like Chlorothalonil, Mancozeb, etc.
```

Fig.15. Testing For Potato Plant Diseases By Loading Image

3) Real Time Plant disease detection

a) By live feed – using webcam

In this section the program here is an implementation of a plant disease detection system using a pre-trained deep learning model (ResNet50) and a webcam. It captures frames from the webcam, preprocesses them, feeds them to the trained model for disease prediction, and displays the prediction result (disease name and recommended pesticide) on the frame. It uses OpenCV library for capturing frames, image preprocessing, and display. The output window will close if the user presses the 'q' key.

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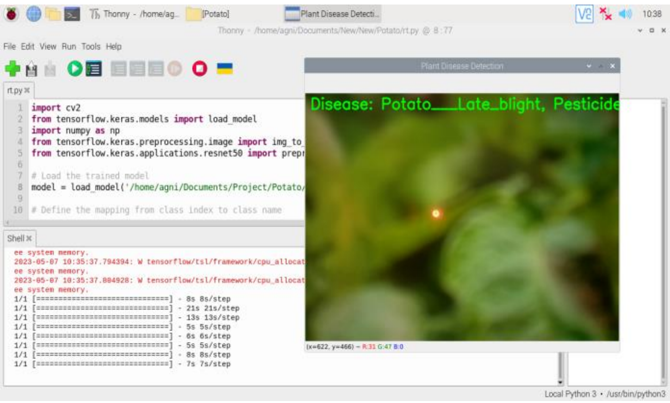


Fig.16. Real time Plant Disease Detection using webcam to detect disease and it's suitable pesticide

b) By live feed using Raspberry Pi Camera – To detect disease and spray suitable pesticide

The program is a Python program for plant disease detection using a webcam and motor pumps for spraying pesticides. The program uses a trained deep learning model to classify the plant disease from the webcam image and recommends the appropriate pesticide for treatment. The program also activates the corresponding motor pump connected to a GPIO pin to spray the recommended pesticide. The program continuously displays the webcam image with the detected disease and recommended pesticide. The program ends when the user presses the 'q' key, and it releases the webcam, cleans up the GPIO pins, and closes the window.

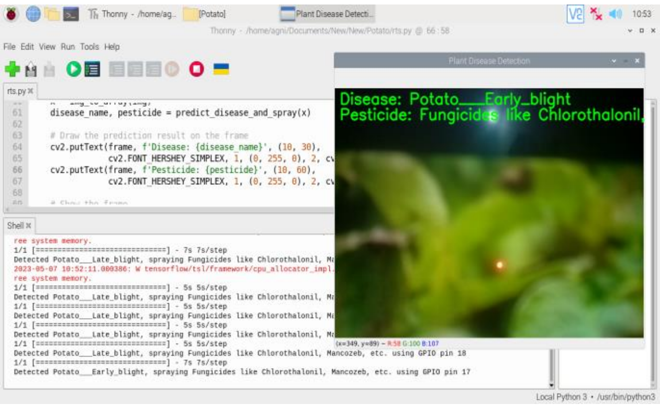


Fig.17. Real time Plant Disease Detection using webcam to detect disease and spray it's suitable pesticide

c) By live feed using Raspberry Pi Camera – To detect disease with percentage of infection and spray suitable pesticide by exciting the motor pump for certain amount of time

The program implements a real-time plant disease detection system using a webcam and a trained deep learning model. The system detects the type of disease affecting a plant in real-time, calculates the percentage of infection, recommends a pesticide to use, and activates a motor pump for the recommended time to spray the pesticide. The system uses OpenCV and TensorFlow for image processing and deep learning, respectively, and RPi.GPIO to control the motor pumps through GPIO pins on a Raspberry Pi. The system also displays the results on the webcam feed and exits upon the user pressing 'q'.

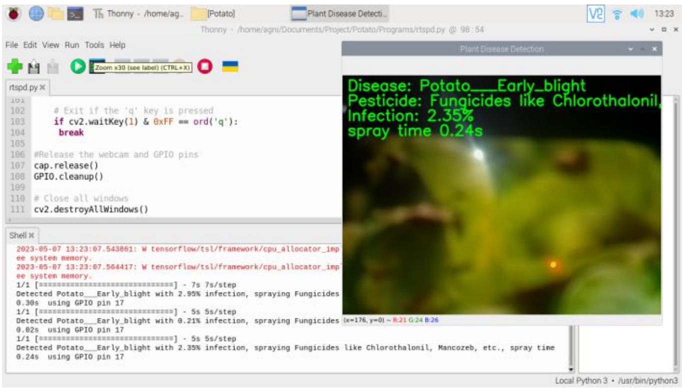
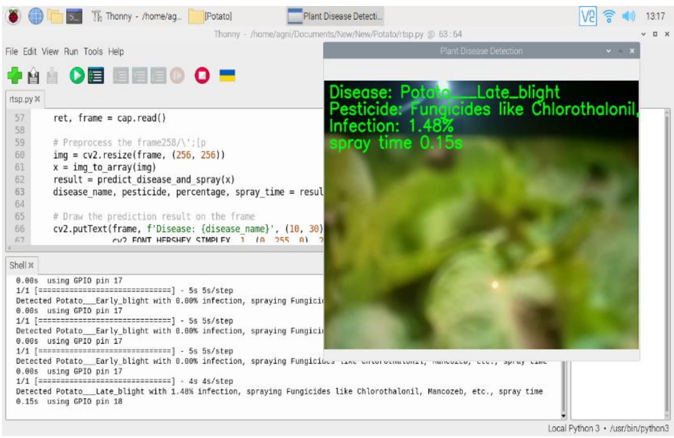


Fig.18. Real time Plant Disease Detection using webcam to detect disease, spray it's suitable pesticide and also calculate percentage of infection and pesticide spraying time

d) By live feed using Raspberry Pi Camera – To detect disease with percentage of infection and spray suitable pesticide by exciting the motor pump based on spraying time

The section has a program which implements a plant disease detection system using a webcam and a trained deep learning model. It detects the disease on a plant leaf by capturing a frame from the webcam, pre-processes it, makes a prediction using the trained model, and activates the respective motor pump for the recommended pesticide. The detected disease, recommended pesticide, and the percentage of infection are displayed on the frame and an OLED display. The system can be stopped by pressing the 'q' key and the webcam and GPIO pins are released at the end of the program.



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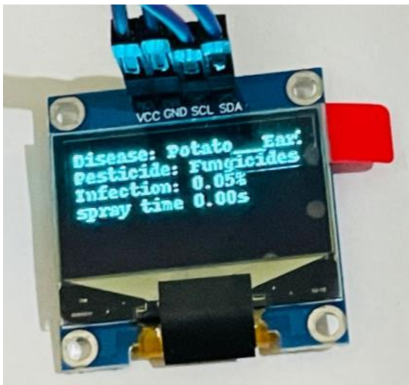

Fig.19. Real time Plant Disease Detection using webcam to detect disease and spray it's suitable pesticide and also display disease, pesticide, percentage of infection and pesticide spraying time on OLED display

4) Localisation of Robot using Arduino Uno and L293D

The section the program controls a 4-wheeled vehicle using an infrared remote control. The vehicle is equipped with four DC motors, which are connected to pins 1, 2, 3, and 4 on an Arduino board using an AFMotor library. The IRremote library is used to receive signals from the IR remote control, which are decoded and used to determine the direction in which the vehicle should move. The vehicle can move forwards, backwards, left, right, and stop based on the IR signal received. The motor speed is set to a fixed value of 255.

B. Hardware Implementation

1) Localisation of Robot using Arduino Uno and L293D

Controlling a 4-wheeled vehicle using an infrared remote involves using an Arduino Uno with an L293D motor shield and a receiver KY022. The IR remote sends signals to the receiver, which is connected to the Arduino. The Arduino then interprets the signals and sends corresponding commands to the L293D motor shield to control the motors of the vehicle. This allows the user to remotely control the movement of the 4-wheeled vehicle.

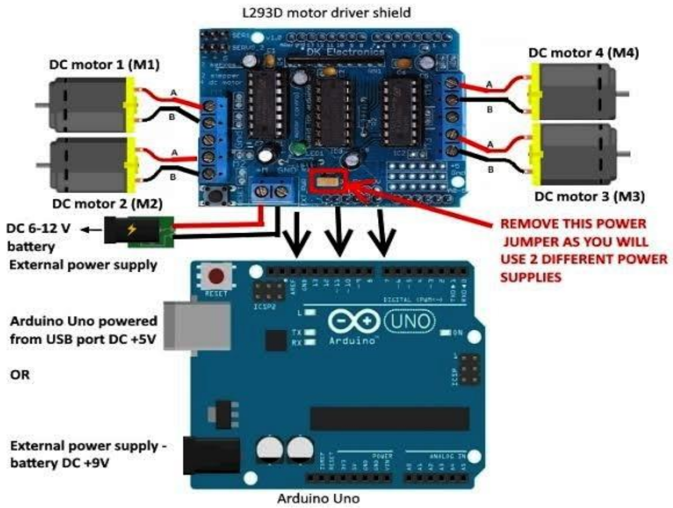

Fig.20. Connection Diagram of Localisation of Robot using Arduino Uno and L293D

2) Real time Plant disease detection by Image Processing using Raspberry Pi 3B+ and Raspberry Pi Camera Module
Real-time plant disease detection by image processing using Raspberry Pi 3B+ and the Raspberry Pi camera module is a system that utilizes computer vision algorithms to analyze images of plants captured by the camera module in real-time. The system detects any signs of plant disease and provides prompt feedback to the user, allowing them to take appropriate action to prevent further spread of the disease. This system is highly efficient and cost-effective, making it a valuable tool for farmers.

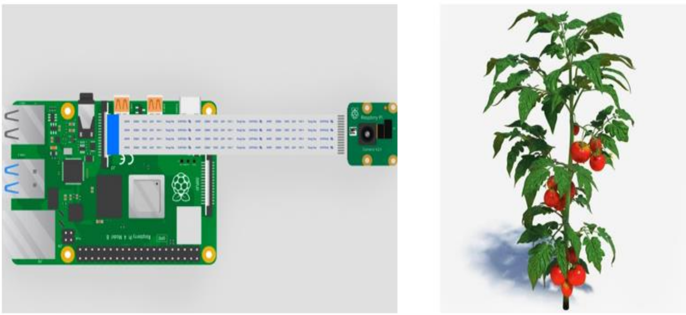

Fig.21. Connection Diagram Of Real time Plant disease detection by Image Processing using Raspberry Pi 3B+ and Raspberry Pi Camera Module

3) Pesticide Spraying Mechanism using Raspberry Pi 3B+ and Relay

The Pesticide Spraying Mechanism using Raspberry Pi 3B+ and relay involves using image processing to detect plant diseases. Once a disease is detected, the system activates a motor to drive a pesticide spraying mechanism for a predetermined amount of time. This helps to efficiently and effectively apply pesticides only when and where

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they are needed, reducing waste and promoting environmentally-friendly practices in agriculture.

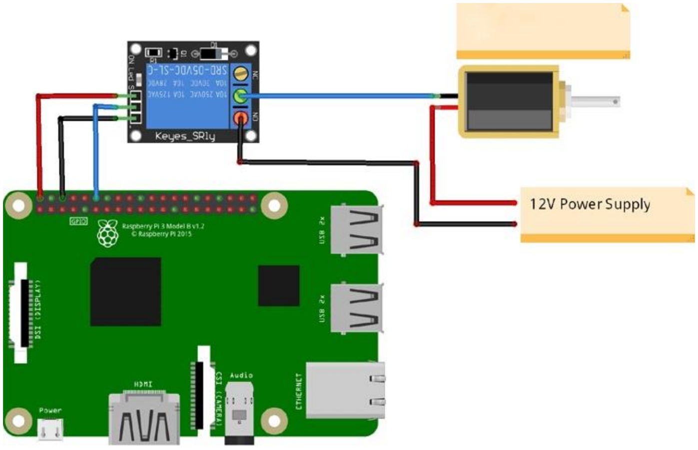

Fig.22. Connection Diagram Of Pesticide Spraying Mechanism using Raspberry Pi 3B+ and Relay

The Complete model implementation of hardware is done in three stages and it is shown in figures 23-25 as below:

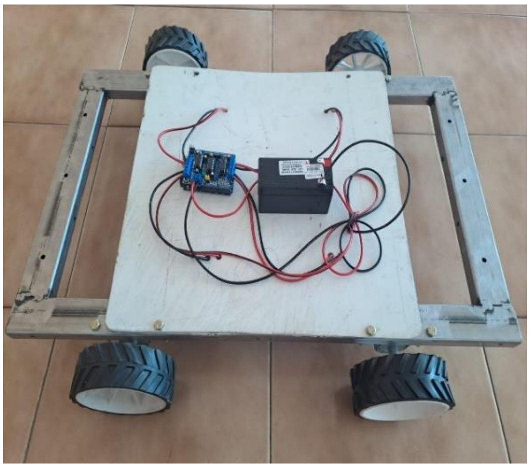

Fig.23. Hardware implementation Stage – 1

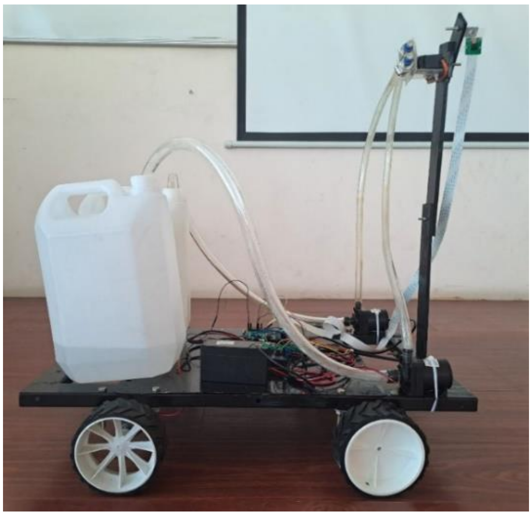

Fig.24. Hardware Implementation Stage – 2

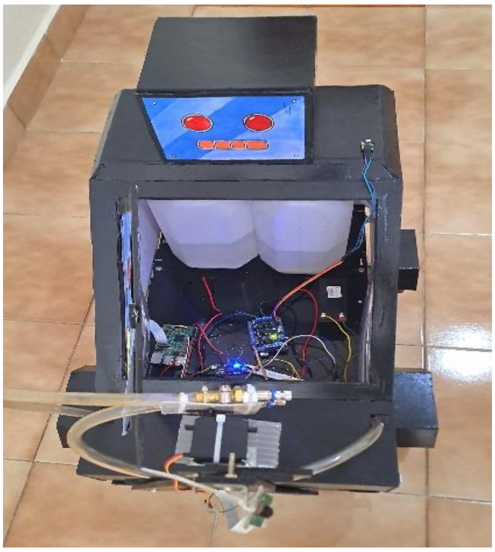

Fig.25. Hardware Implementation Stage - 3

XI. CONCLUSION

The detection and classification of plant diseases is crucial to maintaining the quality and quantity of agricultural products. In this project, a robot is developed to identify and classify plant diseases using image processing techniques and a convolutional neural network. The robot is also programmed to suggest and spray the suitable pesticide on the plant based on the type of disease detected. The project aims to address the major problem faced by farmers, which is the lack of yield due to crop diseases, and provide an early identification of plant disease, mobility for the agriculture field, and suitable fertilizers and pesticides to treat the disease.

The project could be to incorporate a feedback loop to improve the accuracy of disease identification and

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pesticide selection. This could involve collecting data on the effectiveness of the suggested treatment and using it to improve the performance of the convolutional neural network and the robot's decision-making algorithm. Additionally, integrating the robot with a cloud-based platform could enable real-time data sharing and analysis, facilitating more informed decision-making by farmers and improving the overall efficiency of the agricultural system.

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