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Smart Robotic Pythomedic and Pesticide Sprayer using Image Processing and machine learning

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Abstract - Plant-based diseases are a major concern all over the world and in India. Plant-based diseases lead to a reduction of the overall yield of the crop which leads to decreasing the overall income of the farmer. Every year, plant diseases cost the global economy a whopping $220 billion and estimate that 20-40 percent of the crops are lost annually from global food production. (Food and Agriculture Organization of the United Nations. (2019). In the 21st century there are many technical and smart solutions available and can be made to help farmers in a better way, like traditional methods, smart disease detection using machine learning, farming robots etc but most of them are either expensive or difficult for farmers to implement and use. Our Solution is to design a very handy, easy to use solution for the farmers that can help them in identifying the problem that is there in the plant along with helping him smartly in solving the issue. The Smart Spraying robot has a camera in the front which captures the image of the plant and then applies the machine learning algorithm to detect the disease by analyzing the quality of the leaf. We have created our own data set on multiple vegetable plants. We have used a total of more than 3000 images to create our data set which includes three vegetables and in total 10 different leaf conditions.

The robot and the programs are tested in the lab for performance and accuracy. Our Machine learning model works with 100 percent accuracy in detecting the specific disease in the plant leaf. but as it is only trained on 10 different conditions its results are very limited as it can be used only on 3 different vegetable plants. It can be easily scaled to a very big level by making a new machine learning model which will include many more plants and their conditions. It is a viable and implementable solution in the farms which can provide great results.

Keywords- Image Processing, Early plant diseases, Machine learning, Leaf image classification, Agri-robots, Farm-robotics.

1. Introduction:

Plant-based diseases are a major concern all over the world and in India. Plant-based diseases then lead to a reduction of the overall yield of the crop which leads to decreasing the overall income of the farmer. It eradicates the specific yield of the farmers worldwide which decreases the overall world produce and can then potentially develop to major issues such as food security, famine and more. Early identification of these plant-based diseases is extremely tough in rural areas which leads to the crop being spoiled. Food storage is affected by different factors and one of them included plant diseases (Strange, Richard & Scott, Peter. (2005). Plant Disease: A Threat to Global Food Security.) Due to the lack of awareness and knowledge of farmers, they end up putting excessive pesticides and fertilizers which leads to the quality of the overall soil being reduced.

According to the Food and Agriculture Organization of the United Nations, Every year, plant diseases cost the global economy a whopping $220 billion and estimate that 20-40 percent of the crops are lost annually from global food production. (Food and Agriculture Organization of the United Nations. (2019). New standards to curb the global spread of plant pests and diseases). Most of these common diseases can be seen while planting as the quality of the plant can tell us a lot about the diseases that are affecting the plant. Most common are pests and their effect can be seen on the leaves of the plant, along with that there are many disease can can be observed from the condition of the leaves as seen in the pictures below:

Common Problems visible via leaf:

Powdery Mildew: Powdery mildew is a fungal disease that affects a wide range of plants. ... Infected plants display white powdery spots on the leaves and stems. The lower leaves are the most affected, but the mildew can appear on any above-ground part of the plant.

Downy Mildew:Downy mildew refers to any of several types of oomycete microbes that are obligate parasites of plants. Downy mildews exclusively belong to Peronosporaceae. In commercial agriculture, they are a particular problem for growers of crucifers, grapes and vegetables that grow on vines.

Anthracnose: Tomatoes, cucumbers, melons and beans are most often affected by anthracnose. Symptoms include fruits and pods with small, sunken spots. Pinkish spores appear in the center of the spots in wet weather. To control, apply liquid copper or neem sprays before and during infection periods. Begin applications just as leaf buds break in the early spring. In the case of severely infected plants, you'll need to properly destroy them.

Bacterial Leaf Spot:
Infected plants have small, dark water-soaked spots on leaves. These spots will dry up and drop out leaving "shot holes." Small, sunken dark spots or cracks will also form on fruit. Bacterial leaf spot affects tomatoes, peppers and cabbage-family crops in the vegetable garden. There is no cure for plants infected with bacterial spots. Apply copper or sulfur-based fungicides weekly at first sign of disease to prevent its spread. Also, limit high-nitrogen fertilizers, rotate crops and destroy any heavily infected plants.

Club Root:
A serious problem in home gardens, club root infects brassica crops — cabbage, broccoli, cauliflower, etc. — which wilt during the heat of the day. Older leaves turn yellow and drop. Roots are distorted and swollen. Look for disease-resistant varieties and rotate crops. Fungicides will *NOT* treat this soil-dwelling micro-organism.

Early Blight:

Symptoms of early blight include brown and black spots on leaves that enlarge and develop rings like a target. Leaves may actually die. You'll find sunken spots on fruits and tubers. Prevention measures include proper seed selection and using a copper-based fungicide early, two weeks before disease normally appears or when weather forecasts predict a long period of wet weather.

Mosaic Virus:
Affecting a variety of plants including beans, tomatoes and peppers, mosaic virus causes mottled green and yellow foliage or veins. Leaves may curl or wrinkle and plant growth is often stunted. There are no cures for viral diseases such as mosaic. Your best bet is to take preventive measures such as planting resistant varieties and controlling insect pests, especially aphids and leafhoppers, that spread the disease. Remove and destroy infected plants.

Why is it important to study the leaf condition of any plant?
It is really important to study the leaf condition because it is affecting the whole world in multiple ways. One is that it decreases the quality of food, secondly it reduces the quality of soil. It also decreases the crop yield to 30-40% of the global world, and also decreases the income of farmers. Presently farmers use their experience or mostly they cut some crop and show it to the specialist who then gives the needed pesticides or fertilizers.Then farmer uses it on the crop by himself. which leads to most of the farmers using excessive chemicals that affect the quality of the soil. A research by Scroll.in says that every year the use of the fertilizers and pesticides in farming increases by minimum 5 percent. Due to fast industrialization of Indian farming because of the green revolution, Indian farmers started using fertilizers and pesticides to increase the crop yield but after a long time it is now showing its effect on the soil. This happened because of the lack of knowledge and awareness.

2. LITERATURE REVIEW

In the 21st century there are many technical and smart solutions available and can be made to help farmers in a better way. Therefore I thought that there is an urgent need for a simple and smart solution. It is also solvable on a wide scale as smartphones can then access this model and then help in identifying diseases by their advanced and HD cameras. Therefore, this will mean that it can be accessible to everyone and therefore then the model can be used by farmers as a means to identify diseases by simply taking a photo of the plant and then they get the result which can lead them to identify it earlier and solve it.
Following are the solutions available to deal with the disease related to the leaves of the plants:

1. **Using Deep Learning for Image-Based Plant Disease Detection:**

Crop diseases are a major threat to food security, but their rapid identification remains difficult in many parts of the world due to the lack of the necessary infrastructure. The combination of increasing global smartphone penetration and recent advances in computer vision made possible by deep learning has paved the way for smartphone-assisted disease diagnosis. Using a public dataset of 54,306 images of diseased and healthy plant leaves collected under controlled conditions, we train a deep convolutional neural network to identify 14 crop species and 26 diseases (or absence thereof). The trained model achieves an accuracy of 99.35% on a held-out test set, demonstrating the feasibility of this approach. Overall, the approach of training deep learning models on increasingly large and publicly available image datasets presents a clear path toward smartphone-assisted crop disease diagnosis on a massive global scale.

2. **Traditional Method (Symptoms and Diagnosis)**: The chief symptom of leaf spot disease is spots on foliage. The spots will vary in size and color depending on the plant affected, the specific organism involved, and the stage of development. Spots are most often brownish, but may be tan or black. Concentric rings or dark margins are often present. Fungal bodies may appear as black dots in the spots, either in rings or in a central cluster. Over time, the spots may combine or enlarge to form blotches. Spots or blotches that are angular are generally referred to as anthracnose (see entry on "Anthracnose of Trees") Leaves may yellow and drop prematurely.

3. **Integrated Pest Management Strategies**

1. Live with the disease. Most trees tolerate leaf spots with little or no apparent damage. A tree affected early in the year will re-leaf and the new leaves may not be affected. Only if defoliation occurs three or more years in a row will most established plants be adversely affected.

2. Remove infected leaves and dead twigs. Raking up and disposing of infected leaves as they drop and pruning out dead twigs can help control the disease by removing spores that can reinfect the new leaves. This is not a cure but may help limit infection by reducing the total amount of inoculum.

3. Keep foliage dry. Avoid overhead watering. Use soaker hoses or water early in the day so the foliage can dry off before night. Watering can also spread the disease by splashing. Pruning plants to allow for good air circulation and reducing crowding will also help keep the foliage dry.

4. Keep plants healthy. Since most plants can tolerate some defoliation, keep them in good health so they can rebound quickly. Avoid over fertilizing by testing the soil first. Abundant, young, tender growth is very susceptible to attack by disease and insects. Overuse of nitrogen can cause an abundance of succulent growth.

5. Use fungicides if needed. In rare cases of severe infection and where the size and value of plants make it practicable, applications of fungicides may be helpful. Sprays will not cure infected leaves. Therefore, once the damage is noticed, spraying may have limited value. Spraying generally needs to be started as buds break in the spring and repeated at 10–14 day intervals. Recommendations will vary by disease and fungicide used. Have the disease identified before purchasing a control product.

6. Replace the plant. Though a drastic measure, many gardeners find it less bother and more rewarding to replace a plant that is continually plagued with leaf spot diseases. Either replace it with a different kind of plant or a variety that is more resistant or tolerant of disease. A nursery can help you in your selection.

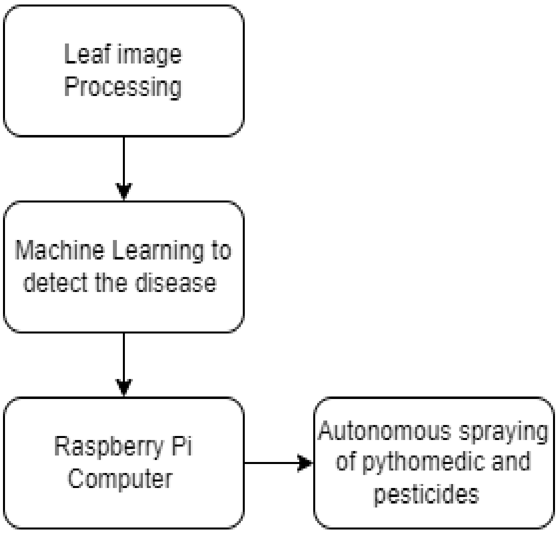
4. **Organic Strategies:** Strategies 1, 2, 3, and 6 are strictly organic approaches. Using an appropriate organic fertilizer would be a viable organic approach to Strategy 4. For an organic approach to Strategy 5, consult the Organic Materials Review Institute (OMRI™) for appropriate organic copper products.

5. **Intelligent Robot System for Spraying Pesticides:**

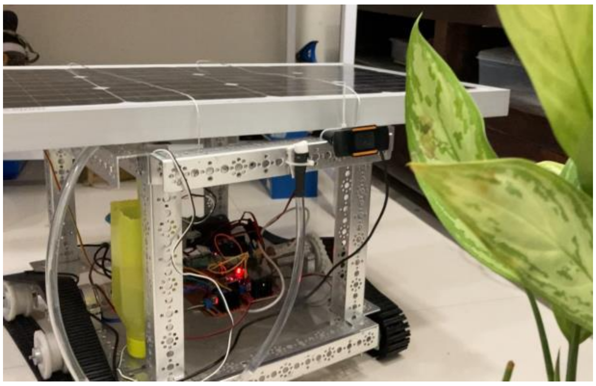
In order to reduce pesticides in agricultural production caused by direct contact with the human body injury, and improve the efficiency of agricultural spraying operations, this paper proposes the design of intelligent WiFi wireless controlled spraying pesticides robots. For monitoring the microcontroller core, a wireless router for the network connection point is employed. The camera captures video, Android phones and smart monitoring system operation. Test results show that the design realizes spraying pesticides by robot to replace staff job, and achieves good results.

6. **Detection of plant leaf diseases using image segmentation and soft computing techniques:** This paper presents an algorithm for image segmentation technique which is used for automatic detection and classification of plant leaf diseases. It also covers surveys on different disease classification techniques that can be used for plant leaf disease detection. Image segmentation, which is an important aspect for disease detection in plant leaf disease, is done by using genetic algorithms.

3. Our Solution



Our Solution is to design a very handy, easy to use solution for the farmers that can help them in identifying the problem that is there in the plant along with helping him smartly in solving the issue.



The Smart Spraying robot has a camera in the front which captures the image of the plant and then applies the machine learning algorithm to detect the disease by analyzing the quality of the leaf.

We have created our own data set on multiple vegetable plants.

We have used a total of more than 3000 images to create our data set which includes three vegetables and in total 10 different leaf conditions.

We have used teachable machines (online machine learning platform) to train our model on the dataset that we have created.

It would work by taking an image as the input which would be taken by the camera of the robot, then using the dataset we have and then identifying the type of plant it is and then goes through the classification of the plant disease assigned to it and then tells which type of plant and plant disease it is as the output which would lead to earlier recognition of the diseases and therefore the robot can decide the type of pesticide or pythomedic need to spray along with the quantity to be sprayed. After collecting all the data and information, the robot will spray the medicine according to the need.

Data & Data Collection:

Here we are having 3 crop species, 10 different types of plant conditions/diseases, and a database containing more than 3,500 images. The dataset is a combination of data recorded by us from a nearby farmer and also data from the internet. 2,993 images are taken as video recordings from nearby plantations and recorded and then converted into images by a code and the rest of the images were taken from the internet. We have used a self created database using python coding. We have clicked videos of various plant leaves by taking four commonly available plants, which are bottle gourd, brinjal and Okra. We clicked the videos of the different leaves like healthy leaves, diseased leaves etc. then after that using a python program and openCV library, we saved every single frame of all the videos in different folders. I Have also collected some images from the internet for better accuracy of the model. After that all the photos were sorted in folders and folders were named after the disease. In that way I have created a fully sorted and labeled database of 3243 images with

10 different labels. All the labels have more than 300 images.

Python code for data collection:

```
import numpy as np
import cv2

cam = cv2.VideoCapture('dyingladyfinger.mp4')
a = 0
while 1:
   ret,frame = cam.read()

   if ret:
      name = 'img'+str(a)+'.jpg'
      print('creating..'+name)

      cv2.imwrite(name, frame)
      a+=1
   else:
      break
cam.release()
cv2.destroyAllWindows()
```

What is "Teachable machine" and why have we used it?

Teachable Machine is a web-based tool that makes creating machine learning models fast, easy, and accessible to everyone.

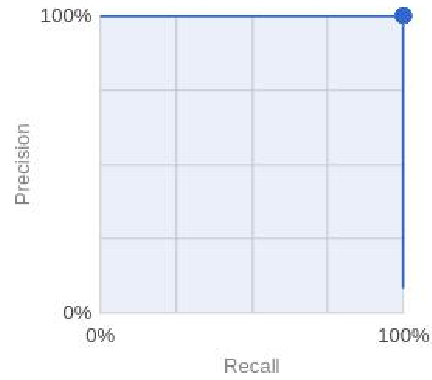
Educators, artists, students, innovators, makers of all kinds – really, anyone who has an idea they want to explore. No prerequisite machine learning knowledge required.You train a computer to recognize your images, sounds, and poses without writing any machine learning code. Then, use your model in your own projects, sites, apps, and more.

Training

2920 images were used for training while 323 images were used for tests. The Data was trained at 8 nodes per hour while it was tested at 1 data point which gave 3.20 queries. The precision, recall and accuracy for each label and the total model was 100%.

All labels

Total images	2,920
Test items	323
Precision	100%
Recall	100%



Python code for detection:

We are using another python code that is using the model that we have trained along with the labels. When the camera takes the picture of the plant, it takes the image as an input and then processes it using the machine learning model.

```
from keras.models import load_model
from PIL import Image, ImageOps
import numpy as np

# Load the model
model = load_model('keras_model.h5')

# Create the array of the right shape to feed into the keras model
# The 'length' or number of images you can put into the array is
# determined by the first position in the shape tuple, in this case 1.
data = np.ndarray(shape=(1, 224, 224, 3), dtype=np.float32)
# Replace this with the path to your image
image = Image.open('healthybhindi.jpg')
#resize the image to a 224x224 with the same strategy
```

as in TM2:
#resizing the image to be at least 224x224 and then cropping from the center
size = (224, 224)
image = ImageOps.fit(image, size, Image.ANTIALIAS)

#turn the image into a numpy array
image_array = np.asarray(image)
 # Normalize the image
normalized_image_array = (image_array.astype(np.float32) / 127.0) - 1
 # Load the image into the array
data[0] = normalized_image_array

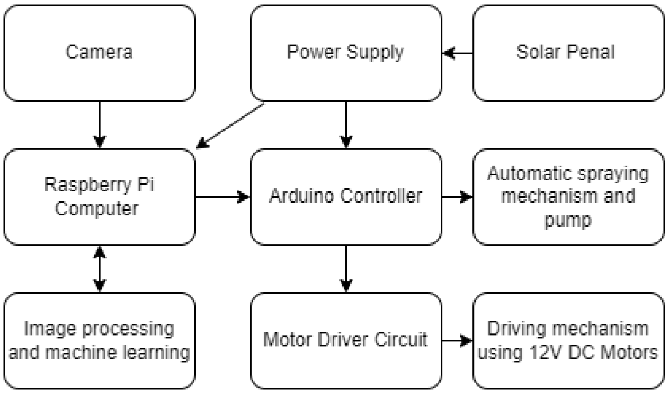
 # run the inference
prediction = model.predict(data)
print(prediction)

Testing of the python program:
For testing I have used 10 different images, 4 from the internet and 6 from phone cameras.
9 out of them were related to the labels on which model was trained and 1 image was not related to the labels and had no match with the preferred data.

After testing the model precisely and accurately detected all the images with the corresponding labels with one undetected and it was not related.

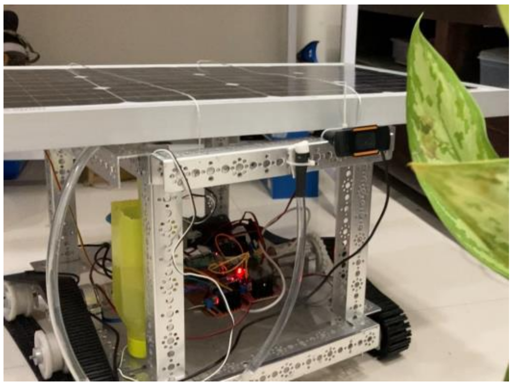
I have tested it multiple times and all the time it gave us 100 percent accuracy in the results.

Robot Specifications:



Robot Consist following components and mechanisms:

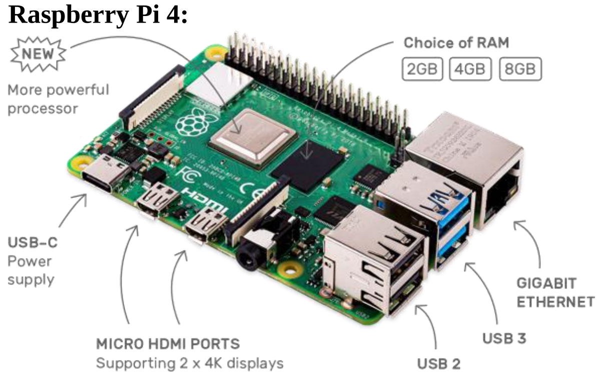
1. **Robot Chassis:**



We have used tetrix aluminum channels to design the mechanical structure of the chassis. It has 2 tetrix DC Geared motors in the driving mechanism.

- To make it go off-terrain we are using belt drive mechanism

2. **Raspberry Pi 4:**



We are using the Raspberry Pi4 as the main computer of the robot . It is the latest and the fastest model available for making smart computer based projects

3. **Logitech webcam:**

We have used a logitech webcam on the robot to take pictures of the plant and its leaves.
This is a 8MP high quality camera which provides us high resolution clear images of the plant and leaves.

4. **Arduino Uno Microcontroller:**

We have used an Arduino uno controller to control the robot. It continuously receives signals from the Raspberry Pi and makes the robot move.

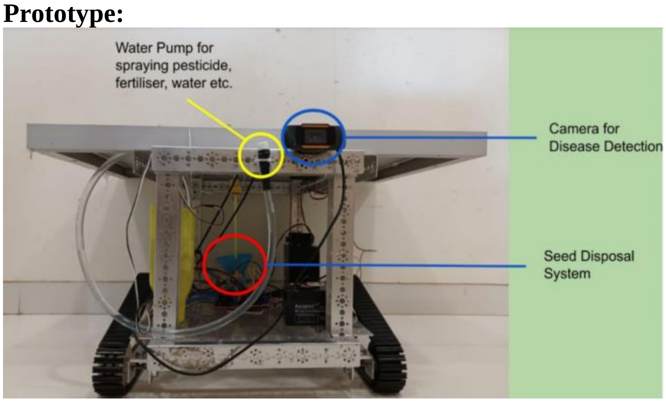
5. **Solar Panel:**

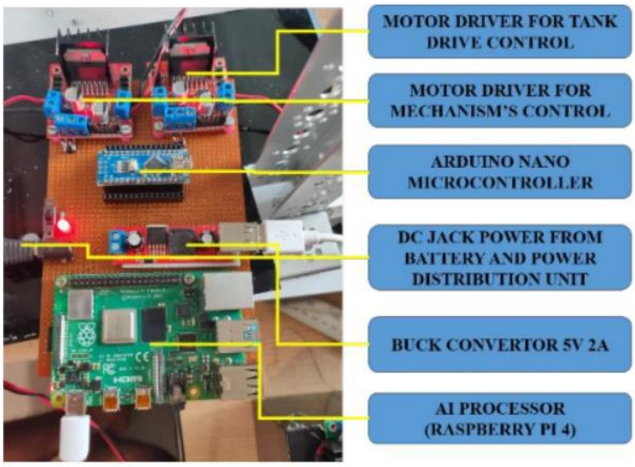
We have installed one 2X3 feet big solar panel on the top of the robot. which provides sufficient power to run the robot smoothly. We have also installed a battery circuit which gets charged when there is sun while the robot is working on panel and then robot can work at night using the power stored in the battery

6. **Motor Driver Circuit**:

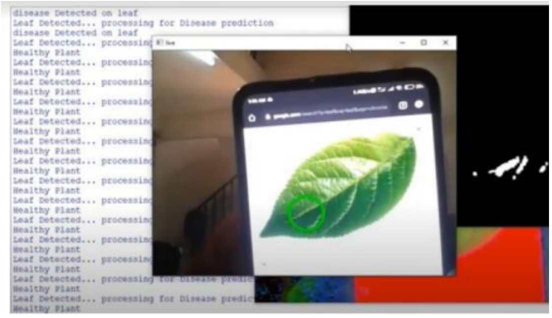
L298 module is a high power efficient motor driver circuit which can give high current to all the high torque DC Motors in the robot circuit.

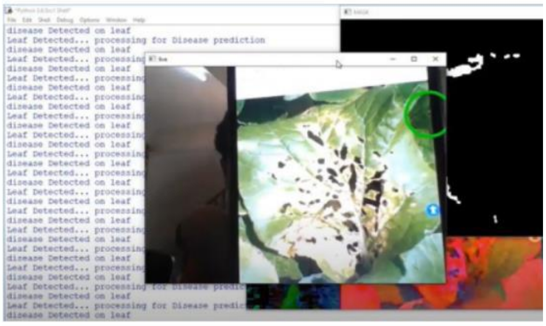
Prototype:





Digital Output:





1. **Future Scope:**

   Our Solution is right now at a prototype stage and it is working efficiently. Our machine learning model is giving us 100 percent accuracy but it is only trained on 3 different plants and in total 10 different conditions, so in future our next step is to increase the data set to a very big level including more than 20 different plants with at least 100 different conditions and diseases. On the other hand there is a big scope of improvement in the design of the robot. Right now our robot is at prototype stage and it is made using very expensive building parts and it is costly. We need to work a lot on designing the robot in future to make it cheaper and more reliable. We will include lots of customisable designing and it also needs to be simpler for the farmer to use it easily.

2. **Conclusion:**

   The robot and the programs are tested in the lab for performance and accuracy. Our Machine learning model works with 100 percent accuracy in detecting the specific disease in the plant leaf. but as it is only trained on 10 different conditions its results are very limited as it can be used only on 3 different vegetable plants. It can be easily scaled to a very big level by making a new machine learning model which will include many more plants and their conditions. Our robot works efficiently. Belt drive mechanism makes it an all terrain robot. It can easily move around the farm and do the task. DC Geared motors provide enough torque to make the robot carry the whole weight of the pesticides and pythomedic easily.

   It has a very sturdy structure and design which is made using Aluminum channels. Power consumption is a concern and needs to be worked on. To conclude we can say that our solution is a viable and implementable solution in the farms which can provide great results.

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