ISSN (Online): 2583-648X

IJIRID

International Journal of Ingenious Research, Invention and Development

An International, High Impact Factor, Double-Blind Peer-Reviewed, Open-Access, Multidisciplinary Online Journal

Volume 3 | Issue 1 | February 2024

Journal Impact Factor 2023 (Quality Score): RPRI = 6.53 | SJIF = 3.647

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Detection of Plant Disease using Deep Learning

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Abstract: *With the increase in world population over the years, the demand for food has increased exponentially. Moreover, Agriculture with its allied sectors is the largest source of livelihood in India. Plant diseases are a major risk factor for food security. Hence it becomes very important to detect the plant diseases in crops accurately and quickly to reduce the damage caused to the crops. Generally, the identification of plant diseases and remedies for those disease is done by experts. This requires the farmers to bear the transportation cost for reaching the experts and the consultation fees charged by the experts for disease detection. To reduce these problems caused to the farmers, they can use automatic plant disease identification. In this process, one can take a photograph of the diseased plant leaves and upload them to our servers. On servers, we use a trained deep learning model (Convolutional Neural Network architecture) to detect the disease in the plant leaf. Then the detected disease is displayed to the user along with the remedy for the disease. The Neural network was trained using more than twenty thousand images of diseased plant leaves and was tested on more than three thousand six hundred images of diseased plant leaves. The trained neural network was found to be able to predict the disease in the leaves with a good accuracy of 97%. This will help reduce all the above-mentioned costs incurred by the farmers and will also save the time and energy of the farmers. In addition to this automatic detecting is more accurate than visual inspection by the experts. It will also keep the historical data and analysis accessible at any time thus improving the handling of the challenges faced due to plant diseases. In this way, our project is aimed towards reducing the hardships faced by the farmers and providing accurate results.*

Keywords: *Deep Learning, Plant Disease Detection, Smart Agriculture, etc.*

I. INTRODUCTION

Problem Statement:

Agricultural productivity in India heavily depends on disease-free plants. However, disease detection is often time-consuming and expensive for farmers, leading to decreased productivity and financial losses. The integration of technology, such as fast internet and mobile phone cameras, presents an opportunity to streamline disease detection processes and minimize resource wastage.

Overview of the Proposed Solution:

This research proposes leveraging concepts from Computer Science, particularly Image Processing and Deep Learning, to develop an automated plant disease detection system. The system will allow farmers to upload images of diseased plant leaves to a web application, which will use a trained deep learning model to accurately diagnose diseases and provide remedies.

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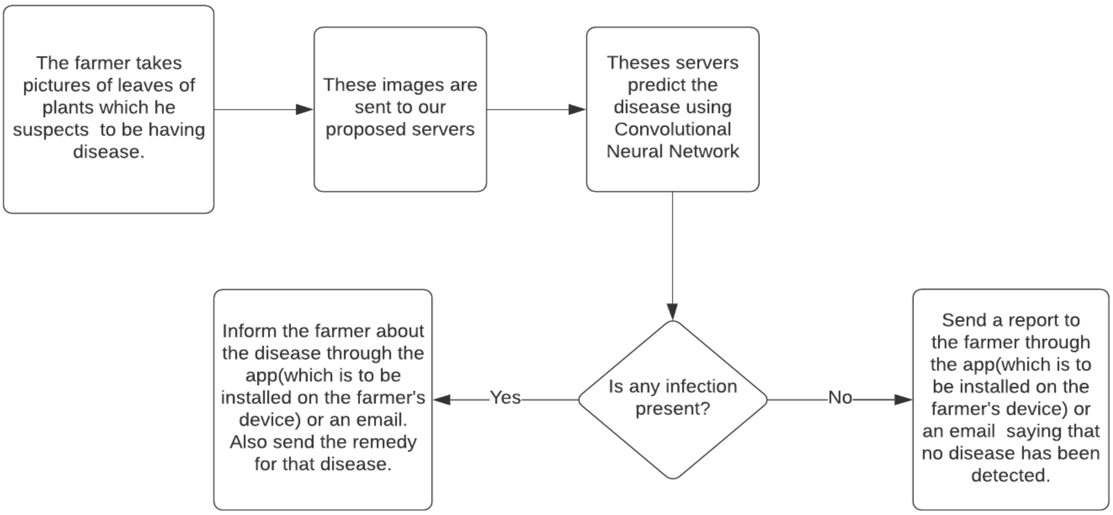

Figure 1.1: Basic Architecture of the System

II. LITERATURE SURVEY

Detection Methods in Agriculture

[1] H. Wang et. al utilized nearest-neighbour interpolation and median filtering for disease detection in wheat and grapevine leaves.

[2] Q. Yao et. Al employed a Support Vector Machine (SVM) with radial basis kernel function for rice plant disease identification.

[3] Ghaiwat et al. compared various strategies for disease identification, highlighting the efficacy of K-nearest neighbours.

[4] Sanjay B et al. proposed a method involving RGB to HSI conversion and green pixel masking for disease detection.

[5] Jayme Garcia et al. surveyed multiple techniques including thresholding, neural networks, and color analysis for disease detection.

[6] S. Arivazhagan et al. described a four-step disease identification process using color transformation, segmentation, and texture analysis.

[7] Mrunalini et al. proposed color co-occurrence and neural network-based approaches for accurate disease detection in leaves.

[8] S. D. Khirade and A. B. Patil discussed techniques like color transformation, histogram equalization, and neural networks for plant disease detection using leaf images.

III. APPROACH

3.1 Image Acquisition

Farmers can capture images of suspected diseased leaves using digital or smartphone cameras, ensuring the focus is solely on the leaf without background interference.

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Figure 3.1: Image of Diseased Leaves

3.2 Preprocessing of Images

Acquired images undergo preprocessing, including size uniformity and noise reduction using techniques like cropping, scaling, and Gaussian filtering.

3.3 Training of the Neural Network

A Convolutional Neural Network (CNN) is trained using a large dataset of labelled images representing various diseases and healthy leaves, enabling the network to categorize images accurately.

3.4 Testing of the Model

The trained CNN undergoes rigorous testing with unseen diseased leaf images to evaluate its accuracy, which is crucial for reliable disease detection.

3.5 Deploying the Trained Model

The trained model is deployed in a user-friendly web application using the Flask Framework, ensuring easy access and an intuitive interface for farmers to detect diseases and obtain remedies**.**

IV. CONCEPTUAL ASPECTS OF THE DEEP LEARNING MODEL

4.1 Convolutional Neural Network

In this research project, the focus is on utilizing a Convolutional Neural Network (CNN), which falls under the umbrella of deep learning algorithms. CNNs are specifically designed for processing images as inputs. They excel at learning various features within an image through learnable parameters known as weights, allowing them to distinguish between different images. compared to traditional classification algorithms, CNNs require less preprocessing, making them more efficient.

The architecture of CNNs is inspired by the organization of the Visual Cortex, specifically in terms of receptive fields and how individual neurons respond to stimuli. Figure 4.1 - CNN to detect diseases in plants.

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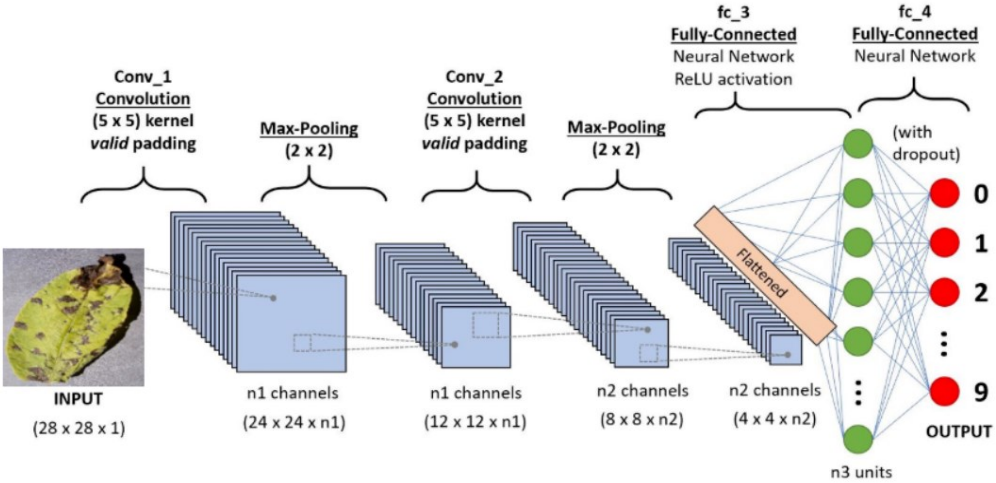

Figure 4.1: RGB Model and Image Processing

Before delving into how CNNs operate, it is essential to understand how computers interpret images using the RGB (Red, Green, Blue) color model. This model separates images into three color planes (Red, Green, and Blue), each representing pixel intensity values ranging from 0 to 255. CNNs work with such high-resolution images efficiently by reducing the pixel count without losing critical features**.**

4.2 Convolution Layer

The core of a CNN is the convolutional layer, which learns image features by convolving small squares of input data with filters. This process preserves pixel relationships and extracts essential features like edges. Convolution involves mathematical operations where image matrices are multiplied with filter matrices to produce feature maps.

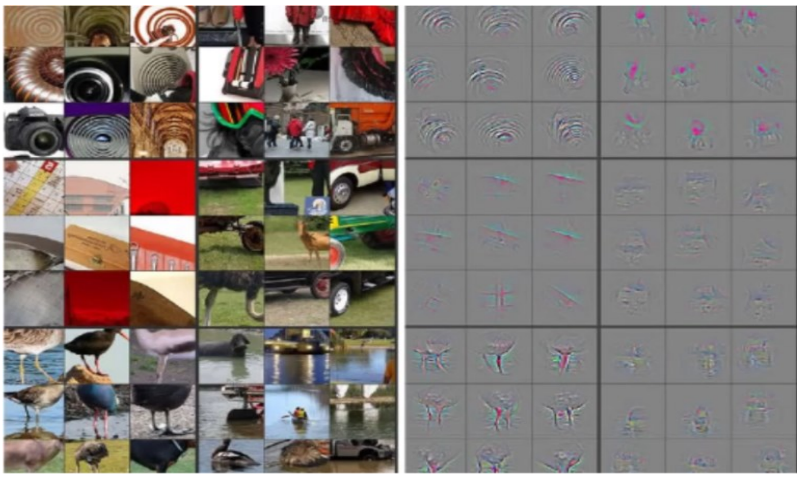

Figure 4.2: Input Images (left), Complicated Features Like Dog Faces and Bird Legs Extracted by the Filters from the Input Images (right)

DOI: 10.5281/zenodo.10964597

ISSN (Online): 2583-648X

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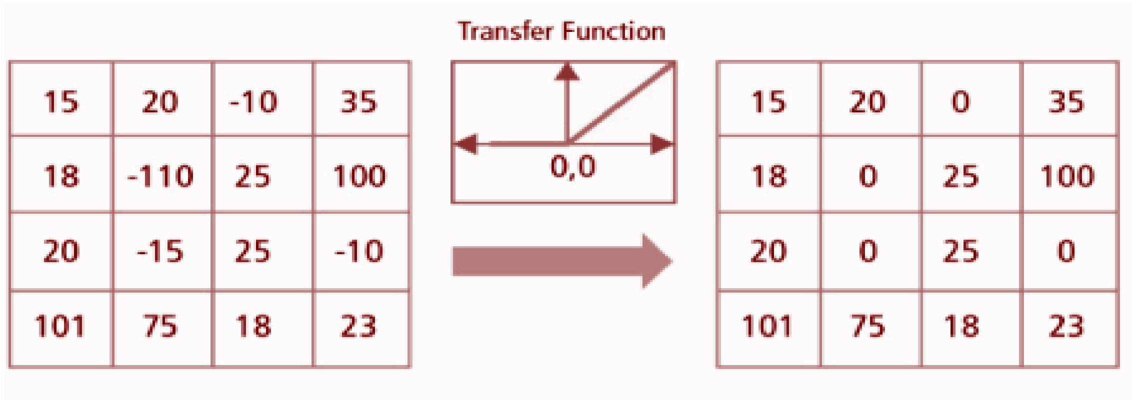

Figure 4.3: ReLU Layer

4.3 ReLU Layer and Pooling Layer

After convolution, CNNs use the Rectified Linear Unit (ReLU) layer to introduce non-linearity, enhancing model capabilities. Pooling layers further reduce feature map dimensions, focusing on major features and aiding computational efficiency. Max Pooling, a common technique, selects maximum values from image sections, enhancing feature extraction**.**

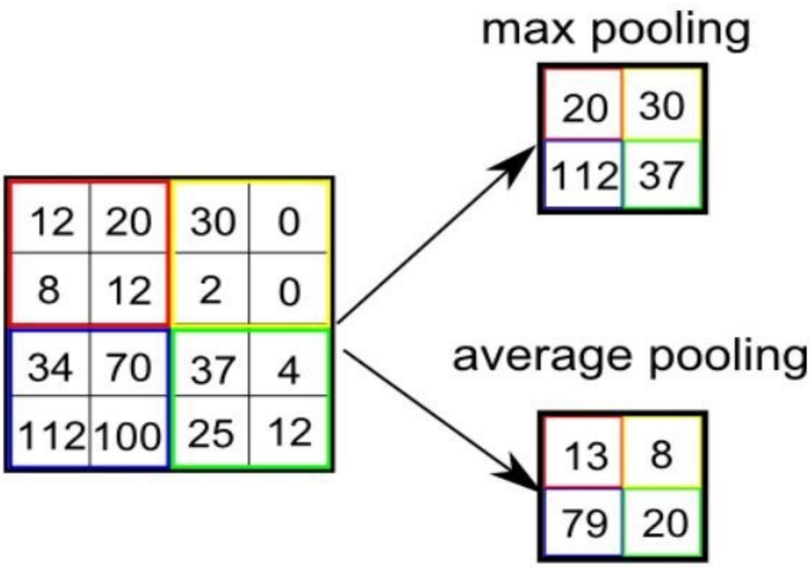

Figure 4.4: Max Pooling and Average Pooling

4.4 Fully Connected Layer (FC Layer)

The final layer in CNNs is the fully connected layer, where features are flattened into vectors for classification. Neural networks process these vectors, applying backpropagation for learning and differentiation between major and minor features. The Softmax Classification technique categorizes input images accurately.

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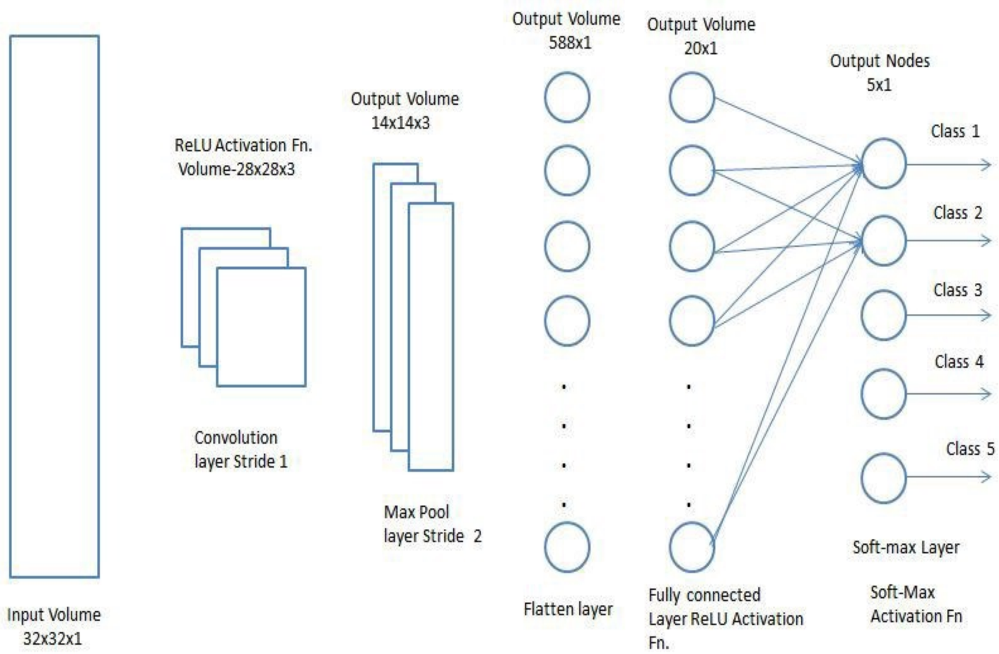

Figure 4.5: Fully Connected Layer (FC Layer)

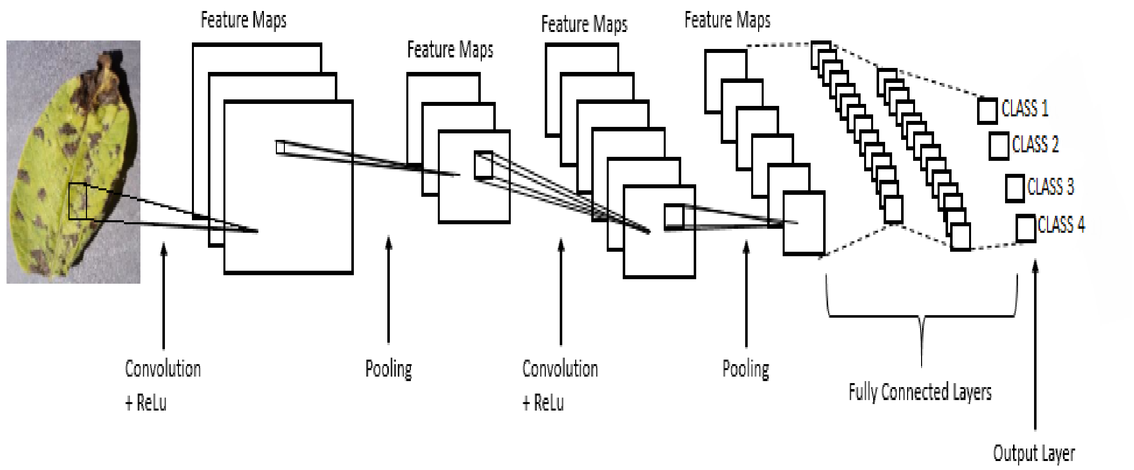

Figure 4.6: Summary of the Convolutional Neural Network

V. IMPLEMENTATION

5.1 Tools, Libraries, and Frameworks Used

Implementing this project required leveraging various tools and libraries. TensorFlow, an open-source machine learning library, formed the backbone for neural network operations. Keras, built on top of TensorFlow, simplified neural network implementation. Additional libraries like OS, Glob, Matplotlib, and Flask facilitated data handling, visualization, and web application development.

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5.2 Dataset

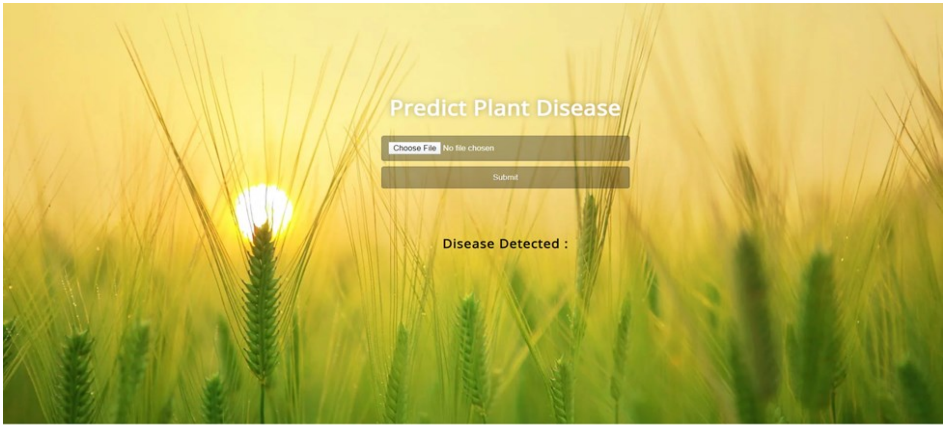
The research utilized a dataset comprising 20,639 images categorized into 15 classes, representing different plant species and diseases. Tomato, bell pepper, and potato plants were the focus, with categories covering healthy plants and various diseases affecting them.

5.3 Building the CNN Model

The process involved loading the dataset, importing necessary libraries, preprocessing data, constructing the CNN model, training it, plotting training metrics, testing accuracy, and saving the trained model. Google Colab, with its free GPU resources, facilitated model training efficiently.

5.4 Demonstration of the Web Application

The web application showcased the trained model's functionality. Utilizing HTML, JavaScript, and Flask, enabled users to upload plant leaf images for disease prediction. The backend, powered by Flask, processed image data using the trained CNN model, accurately predicting plant diseases, and displaying remedies.



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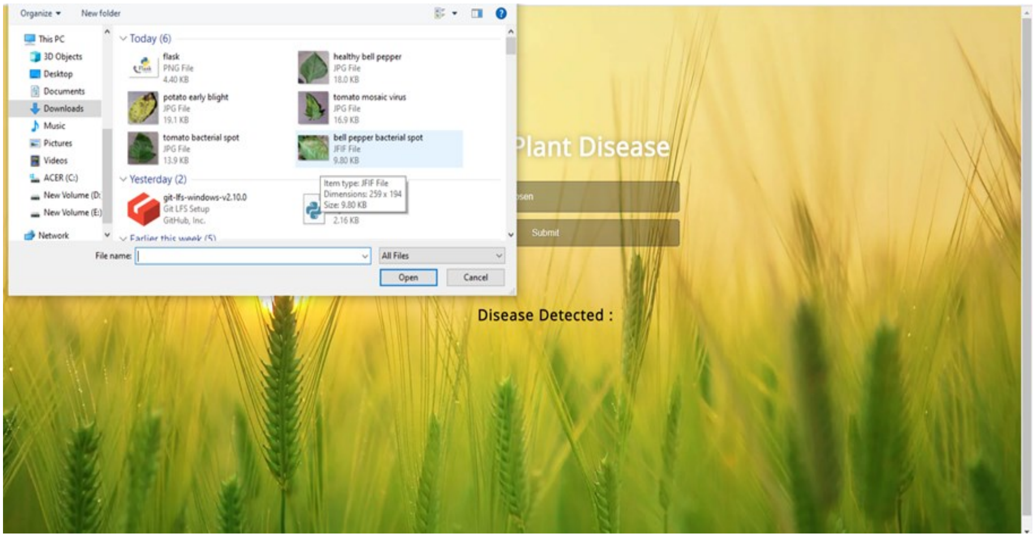

Figure 5.1: Using the Trained Model to Predict the Disease and Display the Output on the Webpage

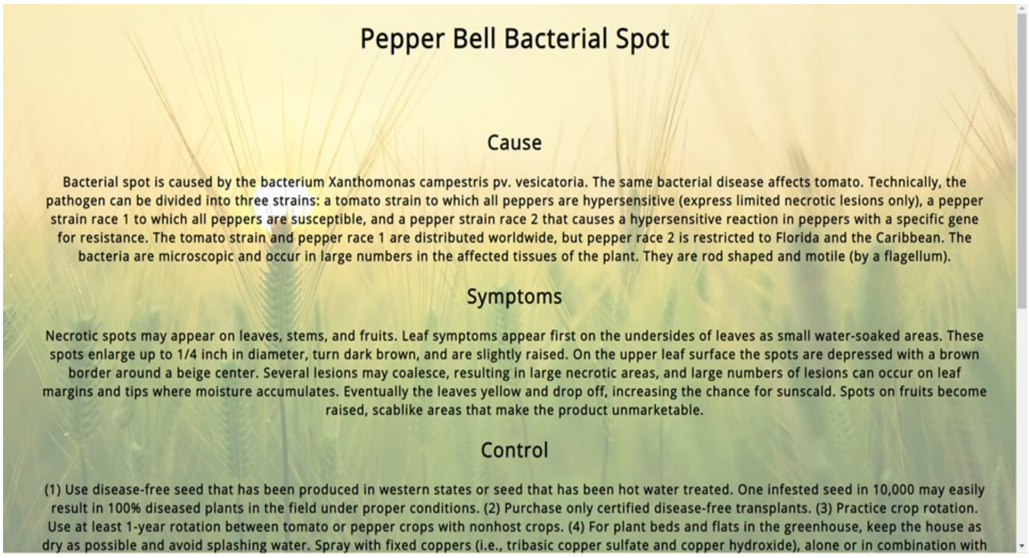

Figure 5.2: Displaying the Remedy for the Corresponding Disease Detected

VI. CONCLUSION AND FUTURE WORK

6.1 Challenges Faced

The project encountered challenges related to dataset quality, domain understanding, computational resources, collaborative work, and model selection. Preprocessing noisy images, understanding plant biology, accessing GPUs, sharing datasets, and optimizing model choice were significant hurdles.

6.2 Key Takeaways

Insights gained included image processing techniques, the importance of ML/DL in agriculture, model selection significance, domain-specific data advantages, and collaborative cloud computing benefits.

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6.3 Significant Achievements

The project achieved high accuracy in disease detection, provided remedies, developed a user-friendly GUI, and utilized cloud resources efficiently, showcasing advancements in plant health monitoring.

6.4 Future Work

Future enhancements could involve deploying the system on drones for real-time crop monitoring, fertilizer estimation, and aerial surveillance, expanding its practical applications in agriculture**.**

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