Tomato Care AI: A Lightweight Client-Side Deep Learning Framework for Tomato Leaf Disease Detection

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***Abstract*—Early and accurate detection of plant diseases is very important as it helps to boost a farmer's output and makes the food supply stronger. However, traditional methods of disease identification depend on manual inspection, which is usually time-consuming, subjective, and unavailable for small-scale farmers. Tomato Care AI, a lightweight browser system that employs deep learning to detect tomato leaf disease, is suggested by the study. The system uses image classification methods to detect diseases that often occur on tomato leaves such as Early Blight and Septoria leaf spot. The system learns on labeled leaf image datasets which is classified into three classes (healthy, early blight and septoria spots) and optimized for efficient performance in low resource devices. From the experiments, it is observed that neural network can be very accurate in classifying disease in plants and CNNs can achieve more than 95% accuracy in a controlled environment. In addition to the classification, the system typically offers an examination of diseases, their causes, and preventative actions. The solution designed shows the use of AI in precision farming and how AI systems could be further developed for better real time decision making.**

***Index Terms*—CNN, Deep Learning, Image Classification, Plant Disease Detection, Precision Agriculture, TensorFlow.js.**

I. INTRODUCTION

Agriculture plays a vital part in feeding the entire globe and achieving stability in the world. Tomato cultivation plays a notable part in the farming industry in India contributing towards the domestic consumption and the livelihoods of farmers. Karnataka, Andhra Pradesh and Tamil Nadu - some of the main tomato producing states, are heavily dependent on the health of the crop to reach sustainable yields. Tomatoes are susceptible to several illnesses, such as Septoria leaf spot and Early Blight. If these illnesses are not identified promptly, tomato crops could be harmed. Environmental conditions and inexperience make manual detection very challenging. Thanks to developments in artificial intelligence technology, particularly learning algorithms, it is now easier to identify tomato plant illnesses from photos. Convolutional neural networks are crucial for extracting information and patterns from images. The existing models depend on cloud computing, which could not be accessible in certain locations. To tackle this issue, the Tomato Care AI model has been introduced. The Tomato Care AI model is simply a technology-based model that can detect diseases of tomatoes. Using images, the model can detect diseases like Early Blight and Septoria Leaf Spot.

The Tomato Care AI model attempts to address the issue of disease detection in areas without cloud computing. The Tomato Care AI Model is our answer to this issue.

II. LITERATUREREVIEW

The existing research on the findings of tomato leaf diseases are observed to have high accuracy using AI frameworks such as hierarchical networks, hybrid models, CNN. Most studies use huge data sets like Plant Village and learn from advanced systems like VGG16, ResNet which helps in achieving reliable accuracy. Most of these systems are, however, developed in high training environment and require

certain resources and hence are not easily accessible to end users, i.e. farmers.

The proposed system, Tomato Care AI, is, however, aimed at practical usability and real-world application than just improving model accuracy. The project's objective is to provide a transfer learning framework that fully utilizes Google Teachable Machine and TensorFlow.js. This eliminates the need for servers and enhances prediction while making implementation simple. Classification seems to be the study's conclusion most of the time. However, our solution improves its quality by offering outputs with disease causes, prospective treatments, and preventive measures. However, there are certain disadvantages to our proposed approach, including a limited range of disease classes and dependence on image quality. It is a better improvement in terms of usability, accessibility, and user-friendliness. For agricultural applications, Tomato Care AI thus highlights a workable, lightweight, and deployable solution.

III. METHODOLOGY

The proposed system uses a structured approach for the spotting of tomato leaf diseases by using a client side deep neural network. The process primarily includes preparing the dataset, then making of a model based on a convolutional neural network (CNN) approach, followed by execution through TensorFlow.js, along with creation of a web-based interface to allow easy user access

A. Dataset Preparation

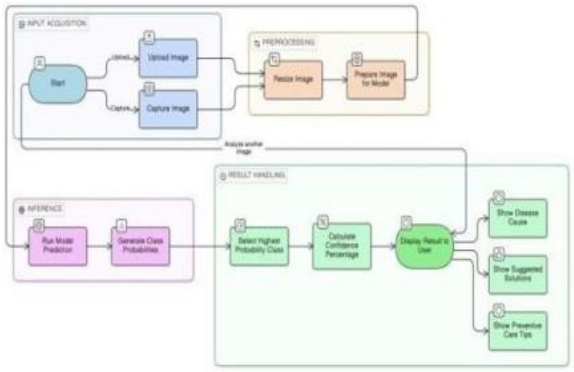
For the teaching process, we collected and labeled a data collection of tomato leaf images. Our dataset is divided into three categories Healthy, Early Blight and Septoria Leaf Spot. These are some of the common diseases found in tomato plants.

All images are preprocessed prior to training. This includes resizing images to a particular resolution a to ensure consistency across the dataset. The date set needs light fluctuations, orientations, and background quality to improve the model's accuracy.

B. Model Framework

This system uses a CNN-based picture classification algorithm based on transfer learning.

The model here is pre trained using the principles of CNN and it uses this data to recognize similar patterns and match it to the correct category Important characteristics including leaf texture, colour variations, and disease-specific spotting patterns can be independently learned by this model. Then, these features are classified into pre-defined classes using a classification layer to allow the system to distinguish between healthy and diseased leaves.



C. Model Training

The model learns by supervised learning on the dataset provided. At this point, the model processes the input images, which are then used to refine the validity of the classification.

The model learns to tell the difference between three classes by looking at things like discoloration or in our case the yellow spots, lesion patterns, and difference in texture. The Teachable Machine platform uses hierarchical learning techniques to expedite the training process.

D. Model Deployment

After training is finished, this model is exported as a TensorFlow.js file and placed on a webpage. The output files contain the model structure (model.json), the trained weights (weights.bin), and the metadata (metadata.json). JavaScript code directs the model into the browser. This design removes the need for server-side processing and enables the system to operate accurately.

E. System Workflow

The system works by following a set of steps that start with user input. First and foremost, the user uploads or takes a photo of a tomato leaf, then taken in the user's browser. Based on the highest likelihood score, the models provide reliable results. This system explains the illness's cause and offers preventative advice.

IV. RESULTS AND DISCUSSION

Our system has been tested on a set of real test images which represents the three classes, i.e., Healthy, Early Blight and Septoria Leaf Spot. The test was carried out in a controlled environment using photos that were clear in terms of lighting and their characteristics. Our solution is successful in showing accurate performance among data set used. The range of 85% to 90% was the average prediction rate. The system was able to detect the visual features such as discoloration of the leaf; distribution of spots and textural differences associated with each class. The system was also able to produce informative outputs successfully such as the causative agent of the disease, recommended solutions and preventive care tips. By providing users with information on the identified condition as well as guidance on possible remedial actions, this enhances the system's practical usability. During the testing process, certain restrictions were noted.

The model may produce inaccurate classifications when given non-tomato photos or highly distorted inputs because it was trained on a small dataset and assumes that the input image is a tomato leaf. In real-world situations where lighting and environmental conditions are less controlled, performance may also vary. The overall findings demonstrate that the suggested approach may preserve usability and efficiency through client-side execution while producing rather accurate and consistent predictions within its scope.

1. Detection of septoria

2. Detection of early blight

3. Detection of healthy leaves

V. FUTURE SCOPE

The suggested Tomato Care AI system shows how client-side hierarchical learning may effectively detect tomato leaf disease. Its practical applications, usability, and functionality still require refinement, nevertheless. The model currently supports only three classes: Healthy, Early Blight, Septoria Leaf Spot. Coming future scope could also include more tomato diseases and pest related issues, improving the system to be even more beneficial for farmers. A larger and more organized dataset may also increase the validity of the model across a diversity of lighting and environmental conditions. We are looking at developing a mobile app version of Tomato Care AI to make it more known and reachable to users on their smart phones.

Real-time disease detection based on device camera would greatly simplify the diagnosis process and give

quick results out in the field. Adding multilingual support can also help farmers to use the app in their local languages. And voice guidance and audio instructions could be helpful for users who are not super tech-savvy. For improvement, we also consider integrating cloud storage and analytics to monitor disease trends in different regions. Weather warnings and tailored treatment recommendations may help prevent crop damage more effectively. All in all, we can say that Tomato Care AI has a great room for improvement to be a smart, affordable and user-friendly tool for precision farming.

VI. CONCLUSION

To conclude, the Tomato Care AI model delivers deep learning to the end user's device directly to make sure the findings of leaf disease symptoms in tomatoes. The algorithm classifies tomato plant leaves into three classes namely Healthy, Early Blight, and Septoria Leaf Spot with the help of transfer learning CNN techniques. In contrast to existing approaches that rely on uploading data in the cloud and processing it with deep learning algorithms, the Tomato Care AI application uses TensorFlow.js within the user's web browser.

Moreover, the graphical interface is simple to access and avoid the confusion with menu options. In addition, Tomato Care AI does not only classify the diseases but also informs users about causes and prevention measures and offers suggestions on how to eliminate the issues from the plants. The presented study proves that user friendly and mobile applications based on deep learning can benefit the agriculture industry significantly.

Overall, Tomato Care AI demonstrates the practical importance of implementing deep learning technology in agriculture. The strategy could enhance yield, decision-making, and crop management.

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