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Coffee Plants Leaf Disease Detection In Deep Learning Algorithm

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Abstract: ***Rust is a severe disease affecting many productive plant leaf regions. It is caused by pathogenic fungi that attack the underside of plant leaf and it is characterized by the presence of yellow-orange and powdery points. If not treated, rust can cause a drop in coffee production of up to 45%. In this sense, this paper presents a contribution to the problem of rust identification that doesn't use "handcrafted" features, i.e., features extracted according to rules established by human programmers. Instead, we propose to train a yolo algorithm to learn to identify rust infection. We evaluated our yolo algorithm in a set of images provided by an expert and comparison results show that our approach is able to detect the infection with a high precision, as corroborated by the high Dice coefficient obtained.***

Keyword : CNN, YOLOv5, Image Processing, Deep Learning, Object Detection.

I. INTRODUCTION

A. Introduction to coffee leaf disease detection

coffee plants are highly susceptible to various diseases that can negatively impact coffee production and quality. Detecting these diseases early is essential to prevent widespread damage to crops. Traditionally, identifying diseases in coffee leaves required manual inspection by experts, which is both time-consuming and often inaccurate. With the advent of deep learning, coffee leaf disease detection can now be automated, offering more precise, faster, and scalable solutions. Deep learning techniques, particularly convolutional neural networks (cnns), have proven highly effective in analyzing images of coffee leaves to detect diseases based on visual patterns.

B. Deep learning models for disease detection

deep learning models, specifically convolutional neural networks (cnns), are the backbone of modern image-based plant disease detection. Cnns automatically learn hierarchical features from input images, making them ideal for tasks such as identifying specific patterns in coffee leaves that indicate disease. In coffee leaf disease detection, cnns are trained on labeled datasets of coffee leaf images, where each image is associated with a specific disease or healthy condition. These models learn to recognize symptoms like discoloration, spots, lesions, and other abnormalities typical of coffee leaf diseases, such as coffee leaf rust (clr) and coffee leaf spot.

C. Dataset creation and preprocessing for coffee leaf disease detection

The success of deep learning models depends heavily on the quality and size of the dataset used for training. For coffee leaf disease detection, a diverse set of images containing both healthy and diseased leaves is required. These images must cover various stages of disease progression, lighting conditions, and leaf orientations. Preprocessing steps like image resizing, normalization, and data augmentation (e.g., rotation, flipping, and cropping) are applied to the dataset to improve the model's robustness. Augmentation helps to simulate real-world variations in leaf appearances, allowing the model to generalize better when deployed in different environments.

Techniques of coffee leaf detection with yolo algorithm

A. Introduction to yolo for coffee leaf disease detection

Yolo (you only look once) is a state-of-the-art deep learning algorithm primarily used for real-time object detection. Unlike traditional methods that perform detection and classification in separate stages, yolo simultaneously predicts

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both the classes and bounding boxes for objects in an image. This feature makes it highly efficient for applications like coffee leaf disease detection, where quick and accurate identification of diseases is crucial. By applying yolo, coffee leaf images can be processed rapidly, allowing farmers or agronomists to detect diseases like coffee leaf rust and coffee leaf spot effectively and in real-time.

B. Dataset preparation and training yolo for coffee leaf disease

To apply yolo for coffee leaf disease detection, a large and annotated dataset of coffee leaf images is needed. These images should contain both healthy and diseased coffee leaves, with clear annotations marking the location of disease symptoms (e.g., spots, lesions, discoloration). The dataset is divided into training and validation sets, and each image is labeled with disease categories. The yolo algorithm is trained on these labeled images using convolutional layers to extract features and make predictions about the presence and location of diseases on the leaves. Yolo’s architecture allows it to efficiently detect disease-related patterns in various conditions, such as different leaf orientations or lighting conditions.

C. Real-time detection using yolo

One of the key advantages of using yolo for coffee leaf disease detection is its ability to perform real-time object detection. Once the model is trained, it can analyze images of coffee leaves and detect diseases almost instantly. Yolo divides the image into grids and assigns bounding boxes around any detected disease symptoms, labeling them with the corresponding disease class. This real-time detection is highly beneficial in practical scenarios where rapid diagnosis is necessary for large-scale coffee farms. With yolo’s speed and accuracy, farmers can quickly spot diseased areas on the leaves and take timely preventive measures.

Advantages of yolo in coffee leaf disease detection

· real-time processing: yolo's speed enables real-time disease detection, ideal for large-scale coffee plantations where rapid identification is essential.
· multi-disease detection: yolo can detect multiple diseases simultaneously in a single image, making it versatile and efficient without needing multiple models.
· disease localization: yolo accurately localizes diseases by drawing bounding boxes around affected areas, allowing farmers to focus on specific regions of the plant.
· improved disease management: by pinpointing exact areas of disease, yolo enhances disease management strategies for better intervention and treatment.
· continuous improvement: advancements in yolo's architecture lead to better performance, higher detection accuracy, and faster results over time.

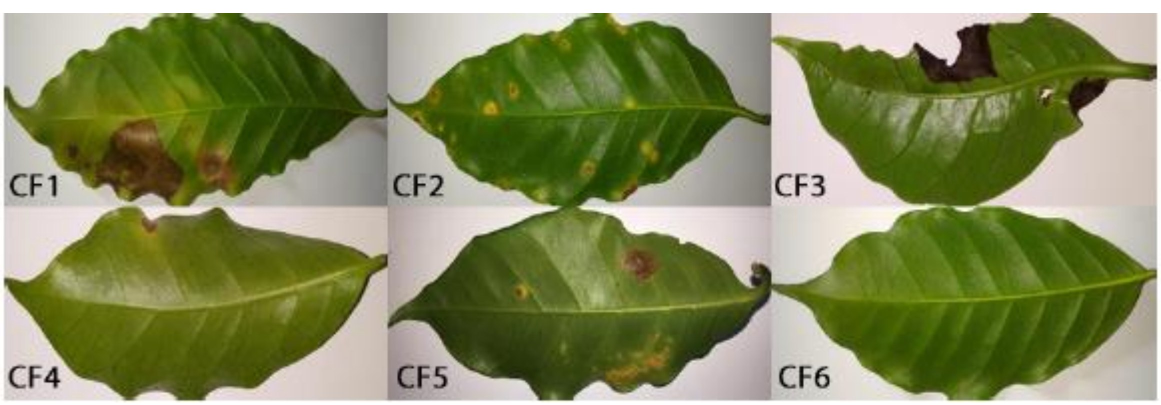

Fig 2.1 (a) sample images from coffee leaf dataset

Some of the images in the coffee disease dataset are downloaded from trusted internet sources. But these are small in number to train any model due to that we captured additional images by ourselves on coffee farms of ethiopia using mobile devices. We did not incur any conditions when capturing the images. Then the images are labeled by researchers at coffee research institute of jimma university. This way a total of 562 images were collected.

Fig 2.1 (b) sample images of affected coffee leaves

But collecting additional data was not possible due to the seasonal nature of the diseases and we could not find archived data in research institutes in the country. We can see from fig. 2.1 (b), the images are representative of the ones present in the natural environment.

II. Related work

Research on acquired images can in different format such as different in dimensions or they have some impurities in the image so we need to perform pre-processing in next step to remove the impurities and reshaping the image, also we need to perform the pre-processing such as image reshaping ,resizing . We cannot compare the image directly with the dataset as images are stored in matrix number, hence we need to convert them to an array for further comparison . A dataset we used had many images of different plant species. The datasets which we collected are used to train the yolo algorithm model so that it can identify the test image and the disease it has or not. Yolo algorithm has different layers that are dense, dropout, activation, flatten,convolution1d,maxpooling1d,convolution2d,maxpooling2d,convolution3d, maxpooling3d using these layers the yolo algorithm model can be trained. After the model is trained successfully the software can identify the disease if the plant species contained . After successful training and pre-processing ,comparison of the test image and trained model is done to predict the disease. In that comparison if the leaf is infected from some disease then it shows the name of that disease and if leaf is not infected then it shows that the leaf is healthy.

Modules

- Image acquisition
- Image pre-processing
- Image segmentation
- Classifiers

Implementation is the stage of the project when the theoretical design is turned into a working system. This is the final and important phase in the system life cycle it is actually the process of converting the new system into a operational one.

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System architecture

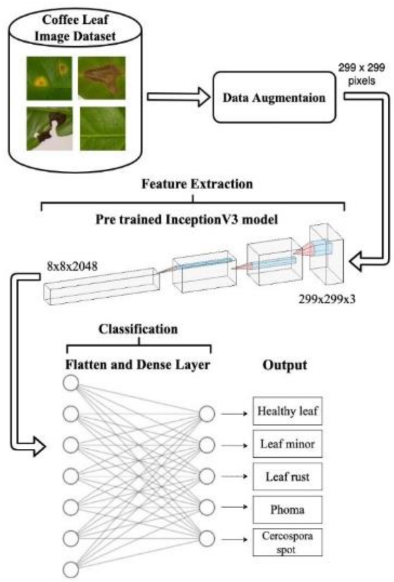

Fig 1.1

In this fig 1.1, they have two phases namely the training phase and testing phase. In the initial phase, they have carried out image acquisition, pre-processed the image and trained the images using yolo algorithm. In the second phase, classification and identification of the disease are done along with pesticide identification. Their dataset has 54,309 images. For training purposes, image is taken from the dataset whereas, for testing, real-time images can be used. For the pre-processing of the image, they have resized the image into a 150×150 dimension. Yolo algorithm method is written using tensorflow. Using this technique, they have carried out classification.[2]the results are shown for training accuracy and testing accuracy for different epochs along with different layers of yolo algorithm i.e. Five, four, three-layer yolo algorithm and class labels of 38 classes and 16 classes. The highest accuracy is obtained for the five-layer model with 95.05% for 15 epochsand the highest testing accuracy achieved is for the five-layer model with 89.67% for 20 epochs.

As the diseases spread rapidly, it is very essential to detect the disease and provide a solution to it. Modern technology is used to recognize the disease and give good accuracy. Yolo algorithm is used to detect visual objects. The model consists of many layers from layer 1 to layer 16. Regularization is achieved by applying batch normalization and dropout [4]. In batch normalization, it will convert the values high in numbers into the range from 0 to 1. By transforming it reduces the time for calculation. The dataset is collected from open sources such as plant village. Secondly, augmentation is done using python. Different transformation is applied to the given image every time. The image data generator class is the pycode that is used in the transformation of the image. All the true cases, false cases are identified and classified. Around 86%of precision is produced.

III. PROPOSED SYSTEM

The proposed network uses a sequential model for classification. This sequential model has been implemented using the keras library in python language. The model has approximately 21 million parameters. Mini-batch gradient descent (mbgd) is the optimization algorithm used to update the parameters. It performs much faster compared to conventional gradient descent algorithms. Fig. 4 represents the proposed neural network architecture. The images provided for training are input into the model in batches. The batch size value is kept as 32 with epoch value as 20. 1488 images belonging to 5 different classes is used for training the model and the image size has dimensions of 299x299 pixels.

Advantages

- It perform high accuracy.
- It detected in real time.
- Low risk, and cost effective.
- Scope of improvement.
- Efficient of handling things.

IV. RESULT AND DISCUSSION

The study proposed a model for classifying and detecting nutritional deficiencies in coffee plants using image processing yolo algorithm. Nutritional deficiencies in boron, calcium, iron, nitrogen, phosphorus, potassium, magnesium and zinc were correctly classified using the proposed algorithm. Based on the result of evaluation, yolo algorithm provide a high level of accuracy in terms of detecting and classifying the nutritional deficiencies in coffee plants. High accuracy for classification can be obtained using numerous numbers of images. The level of detection and classification could also be acquired depending the size of leaves, the higher threshold value for smaller leaves.

V. CONCLUSION

In conclusion, yolo offers a highly efficient and accurate solution for coffee leaf disease detection, revolutionizing the way farmers identify and manage plant diseases. Its real-time processing capability is crucial for large-scale coffee farms, enabling rapid response to disease outbreaks. The ability to detect multiple diseases in a single image further enhances its versatility and reduces the need for multiple models. Yolo’s precise localization of disease symptoms allows farmers to target specific areas of affected plants, improving the overall management of crops. As yolo's architecture continues to evolve, its detection accuracy and speed will only improve, offering even more effective tools for sustainable coffee farming. This advanced deep learning technique holds great promise in minimizing the impact of plant diseases, ultimately leading to better yields and healthier crops. With continued development, yolo could become an indispensable tool in modern agriculture.

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