AI Based Leaf Disease Detection System

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***Abstract*—When plants and crops are affected by pests it affects the agricultural production of the country. Usually farmers or experts observe the plants with naked eye for detection and identification of disease. But this method can be time processing, expensive and inaccurate. Automatic detection using image processing techniques provide fast and accurate results. This paper is concerned with a new approach to the development of plant disease recognition model, based on leaf image classification, by the use of deep convolutional networks in coffee plants. By image processing technique it will automatically detect the disease around the plant, accordingly it will spray the pesticides in controllable manner. In addition to this it will also monitor the health of plant by real time checking of soil moisture, atmospheric humidity, temperature and pH of the plants. All essential steps required for implementing this disease recognition model are fully described throughout the paper, starting from gathering images in order to create a database, assessed by agricultural experts, a deep learning framework to perform the deep CNN training. This method paper is a new approach in detecting plant diseases using the deep convolutional neural network trained and finetuned to fit accurately to the database of a plant's leaves that was gathered independently for diverse coffee plant diseases. The advance and novelty of the developed model lie in its simplicity; healthy leaves and background images are in line with other classes, enabling the model to distinguish between diseased leaves and healthy ones or from the environment by using CNN.**

***Index Terms*—CNN, image processing**

I. INTRODUCTION

Plants play an essential role in conserving the ecological cycle and maintaining the pyramid of food chain. The problem of efficient plant disease protection is closely related to the problems of sustainable agriculture. Inexperienced pesticide usage can cause the development of long-term resistance of the pathogens, severely reducing the ability to fight back. Timely and accurate diagnosis of plant diseases is one of the pillars of precision agriculture.There are several ways to detect plant pathologies. Some diseases do not have any visible symptoms, or the effect becomes noticeable too late to act, and in those situations, a sophisticated analysis is obligatory. However, most diseases generate some kind of manifestation in the visible spectrum, so the naked eye examination of a trained professional is the prime technique adopted in practice for plant disease detection. An automated system designed to help identify plant diseases by the plant's appearance and visual symptoms could be of great help to amateurs in the gardening process and also trained professionals as a verification system in disease diagnostics. Advances in computer vision present an opportunity to expand and enhance the practice of precise plant protection and extend the market of computer vision applications in the field of precision agriculture. Exploiting common digital image processing techniques such as color analysis and thresholding were used with the aim of detection and classification of plant diseases.

II. PROJECT RETROSPECTIVE

AI-based leaf disease detection systems have the potential to revolutionize agriculture by enabling early detection and treatment of plant diseases. These systems use deep learning algorithms to analyze images of plant leaves and identify signs of disease. The algorithms are trained on large datasets of images of diseased and healthy plant leaves. One of the main challenges of AI-based leaf disease detection systems is the need for high-quality images of plant leaves. The images must be taken under controlled conditions to ensure that the lighting and background are consistent. Another challenge is the need for large datasets of labeled images to train the deep learning algorithms The accuracy of the system depends on the quality and size of the dataset. Despite these challenges, AI-based leaf disease detection systems have several advantages over traditional methods of disease detection. They are faster, more accurate, and less expensive than manual inspection by human experts. They can also detect diseases at an early stage, before visible symptoms appear, which can help prevent the spread of the disease. In the future, AI-based leaf disease detection systems are expected to become more sophisticated and accurate as the algorithms are refined and more data is collected. They may also be integrated with other technologies, such as unmanned aerial vehicles and the Internet of Things, to provide real-time monitoring of plant health[6]. However, there are still challenges to be addressed, such as the need for high-quality images and large datasets, before these systems can be widely adopted in agriculture.

III. METHODOLOGY

The leaf disease detection of leaves and plant parameters monitoring were implemented using machine learning process along with several hardware components.To increase the accuracy of the model ,only one type of plant leaves, that is coffee leaves were selected.The dataset of coffee leaf diseases are built with 3 types of common disease namely, cercospora,phoma leaf rust . Preprocessing of these dataset images involves removing noise, removing reflections masking portions of images.To train the images, deep convolutional neural network is used along with tensorflow software.To detect the disease, the picture of input leaf are caught using high definition camera having RGB components.Then image is preprocessed into gray scale.The third phase is image segmentation using k-means algorithm.Then features of image such as color,segment ,texture etc. is extracted.The disease is classified along with visual representation of image processing of uploaded leaf and display the name of disease. When it detect the disease,the LCD board on hardware part displays it ,then corresponding pesticide automatically sprays on plant.Along with these,by using soil moisture sensor, pH sensor and temperature sensor with arduino uno board , displays the parameters on LCD board in real time.
Image processing steps are:

1) Image Acquisition: The pictures of the leaves are caught using the high definition camera having RGB components not the gray scale. Shading change segments of the leaf picture are distinguished, and after that, forwarded to a device capable of autonomous shading change.

2) Image Preprocessing: To expel commotion in a picture or elective article expulsion, entirely unexpected pre-preparing procedures are considered. Picture cutting, for instance, editing of the leaf picture to instigate the intrigued picture locale. Picture smoothing is done through the smoothing channel. Picture improving is managed for expanding the qualification. The RGB pictures into the dark pictures abuse shading change utilizing condition i.e. f(x)=0.299*R + 0.58*G + 0.114*B Equation(1) shows that an image can be defined as a two-dimensional function, f(x, y), where x and y are spatial (plane) coordinates, and the amplitude of f at any pair of coordinates (x, y) is called the intensity or gray level of the image at that point.


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Fig. 1. Conversion of RGB into gray

3) Image Segmentation: The third phase is segmentation, means that image partitioning into numerous portions and segments of similar intensities and similarities. The process of segmentation is often done in many ways using algorithms for instance Otsu methodology, HIS model, k-means algorithm, etc.
The segmentation mistreatment boundary edge detection: The image from the acquisition phase is taken into account and forwarded to the HIS model. The program for edge and spot detection runs the main program and detects the infected diseased part of the plant.
K-means algorithm for clustering: K-means algorithm is employed for clustering and classification of objects supported by a group of options into K variety of categories. The grouping of objects is done by minimizing the gap between them and therefore forming the desired group.

4) Feature Extraction: The process of features extraction plays a vital portrayal in disease symptoms identification. In several applications of image processing, feature extraction is employed. The components such as, color, segments, texture, edges, shades etc. are various distinguishable options which are then utilized in detection of any symptoms.

5) Classification: The fifth phase after feature extraction is classification that means the educational information pictures are classified using a neural network. The segmented features extracted from the output as image are taken as the inputs for this classification phase. Convolutional neural network algorithms are used for the optimum classification. It matches the information from the classified portions with the databases previously stored and helps in exact detection of the disease. For the implementation of this system, we require hardware as well as software components.

A. Hardware

1) ARDUINO (ATmega328P): The ATmega328/P is supported with a full suite of program and system development tools including: C Compilers, Macro Assemblers, and Program Debugger/Simulators, In-Circuit Emulators, and Evaluation kits. The Atmel AVR® core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in a single instruction executed in one clock cycle. Arduino UNO board is the best board to get started with electronics and coding. It can be powered by using the USB cable from computer. All we need to do is connect the USB cable to the USB connection. All the sensors are connected to the Arduino.

2) DHT11: DHT11 can measure temperature from 0°C to 50°C with ±2.0°C accuracy, and humidity from 20 to 80 with 5 percent accuracy. Inside the DHT11, there is a humidity sensing component along with a Thermistor. Humidity sensing component has two electrodes with moisture holding substrate sandwiched between them. The ions are released by the substrate as water vapor is absorbed by it, which in turn increases the conductivity between the electrodes. The change in resistance between the two electrodes is proportional to the relative humidity. Higher relative humidity decreases the resistance between the electrodes, while lower relative humidity increases the resistance between the electrodes. Note that the sampling rate of the DHT11 is 1Hz, meaning you can get new data from it once every second.

3) Soil moisture sensor: The soil moisture sensor consists of two probes which are used to measure the volumetric content of water. The two probes allow the current to pass through the soil and then it gets the resistance value to measure the moisture value. When there is more water, the soil will conduct more electricity which means that there will be less resistance. Therefore, the moisture level will be higher. Dry soil conducts electricity poorly, so when there will be less water, then the soil will conduct less electricity which means that there will be more resistance. Therefore, the moisture level will be lower.

4) pH sensor: A pH sensor is used for measuring acidity or alkalinity of soil.It measures a value between 0 to 14.when pH value is below 7 ,it will become more acidic and when it above 7 more alkaline .It is used to measure the quality of soil.

5) Buzzer: A buzzer is used for the detection of moisture content. In the absence of moisture content or if the moisture content is very low, buzzer starts buzzing. When the moisture content is present, buzzer will not alarm.

6) H Bridge Motor Driver: L293D is a dual H-bridge motor driver integrated circuit (IC). Motor drivers act as current amplifiers since they take a low-current control signal and provide a higher-current signal. This higher current signal is used to drive the motors. L293D contains two inbuilt H-bridge driver circuits. Motor driver is connected to a suction pump and it will starts to spray the pesticide ,when the leaf is detected with disease.

B. Software

1) OpenCV: OpenCV is a large open-source library for computer vision, machine learning, and image processing. It now plays a significant part in real-time operation, which is crucial in modern systems.

2) Tensorflow: TensorFlow is a free and open-source software library for machine learning and artificial intelligence. It can be used across a range of tasks but has a particular focus on training and inference of deep neural networks.

3) Arduino software: The Arduino Uno can be programmed with the Arduino software (download). Select ”Arduino Uno from the Tools Board menu (according to the microcontroller on your board).

4) Python 3.7: Python is an easy to learn, powerful programming language. It has efficient high-level data structures and a simple but effective approach to object- oriented programming.

5) Arduino Development Environment: The Arduino development environment contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions, and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.

6) Writing Sketches: Software written using Arduino are called sketches. These sketches are written in the text editor. Sketches are saved with the file extension .ino. It has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The Arduino environment uses the concept of a sketchbook: a standard place to store your programs (or sketches).

IV. RESULTS AND DISCUSSION

The Results presented in this section are related to training with the whole database containing both original and augmented images. As it is known that convolutional networks are able to learn features when trained on larger datasets, results achieved when trained with only original images will not be explored. After fine-tuning the parameters of the network, an overall accuracy of 96.77 was achieved. Furthermore, the trained model was tested on each class individually. Test was performed on every image from the validation set. As suggested by good practice principles, achieved results should be compared with some other results.

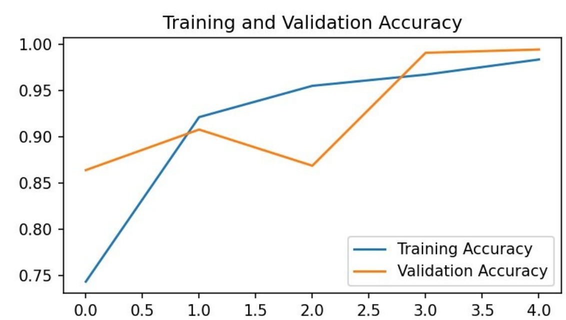

Fig. 2. Training and validation accuracy

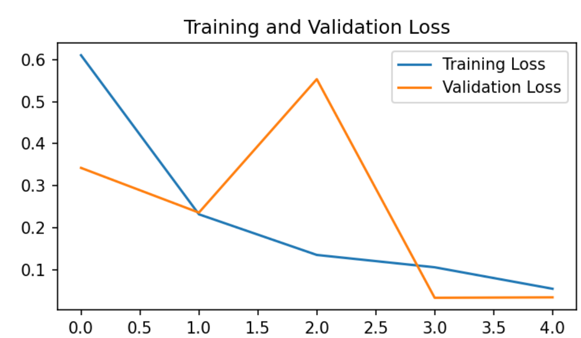

Fig. 3. Training and validation loss

The given disease affected leaves of coffee plant will be successfully classified as cerocospora, phoma or leaf rust. According to the detected disease, particular pesticide will spray along with real time monitoring of soil moisture, pH sensing and temperature sensing of corresponding plant.
In addition, there are still no commercial solutions on the market, except those dealing with plant species recognition based on the leaves images. In this paper, an approach using deep learning method was explored in order to automatically classify and detect plant diseases from leaf images. The complete procedure was described, respectively, from collecting the images used for training and validation to image preprocessing and augmentation and finally the procedure of training the deep CNN and fine-tuning.

V. Conclusion

In conclusion, an AI-based leaf disease detection system is a very efficient tool for recognising and categorising different forms of diseases that might impact plant leaves. The methodology for developing such a system involves collecting a diverse data-set, preprocessing and extracting relevant features from the images, developing a deep learning model, evaluating its performance, deploying the system, and continuously improving it with new data. Compared to more conventional techniques of disease identification, such as human visual examination, AI-based leaf disease detection systems have many advantages. These systems can quickly and accurately interpret enormous amounts of data, making it possible to identify diseases early on, which is essential for efficient disease management. Early disease detection allows farmers to take the necessary precautions to stop the disease's spread and reduce crop damage. Furthermore, AI-based systems are not influenced by human prejudices, which may lead to incorrect or contradictory diagnoses. We can increase the productivity and health of our crops by ongoing research and development in this field, helping to ensure a more sustainable future for the world.

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