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Efficient plant leaf disease identification Material Fabrication using lightweight device

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A B S T R A C T

A lightweight device is constructed to build the powerful plant leaf disease identification scheme with intelligent leaf scanning mechanism. Now-a-days agriculture related fields are getting more attention and importance to take care with as well as the disease identification over leaves can save the entire agricultural field from the affection. An affection caused on a single plant need to be identified in initial stages to prevent the whole farm affection. In literature there are multiple plant leaf disease detection schemes are available but all are strucked under certain constraints such as lacking of cost efficiency, poor execution time, performance, accuracy and so on. In this paper, a new lightweight smart device is introduced called SmartBox, in which it operates based on the Intelligent Leaf Scanning Mechanism (ILSM). This ILSM approach is associated with the SmartBox, in which the SmartBox is constructed with certain intelligent components such as Camera and WiFi. These two components are integrated into the SmartBox to collect the plant leaf images from the agricultural land and pass it to the server unit for processing. In the server end the ILSM is activated to identify the diseases present into the leaf as well as notify that to the farmer to take an appropriate action to prevent the farm land further. This ILSM mechanism associates the deep learning based classification logic to classify the leaf images with respect to affected and non-affected regions. This paper provides the practical proof for the classification efficiency of the proposed approach as well as the disease identification norms in clear manner.

1. Introduction

India is an agriculture country, with approximately 80% of the economy dependent on agriculture and the farmers have a wide variety of options when it comes to picking appropriate crops and pesticides for plants. Plant disease significantly affects the quality and availability of farm products as well as the term "Plant-Disease-Analysis" refers to the examination of visually discernible patterns on plants and monitoring the health and disease status of plants is critical for effective crop cultivation on the farm. Historically, analysis and evaluation of plant diseases is carried out manually by a specialist in that area. This involves an enormous amount of effort and an inordinate amount of processing time. The area of Digital Image Processing methods can be applied to the identification of plant diseases and typically, disease signs are visible on the leaves, stem, and fruit. For disease detection, the plant leaf that exhibits disease symptoms is considered. This article provides an overview of the image processing techniques used to identify plant diseases with Intelligent Leaf Scanning Mechanism (ILSM) associated lightweight smart device called 'SmartBox'.

The identification of plant diseases is critical for avoiding yield and quantity losses in agricultural products as well as the study of plant diseases entails the examination of visually discernible patterns on the plant. Monitoring plant health and disease detection is essential for the sustainable agricultural production and manually monitoring plant diseases is extremely difficult. It takes a great deal of effort, expertise in plant diseases and an inordinate amount

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of processing time. As a result, digital image processing has been used to identify plant diseases and the associated detection entails many stages, including image acquisition, Pre-Processing, Feature Extraction and Classification [10]. This article explored the methods for detecting plant diseases using photographs of their leaves and additionally, this article covered several feature selection and feature extraction algorithms used in the detection of plant diseases. The SmartBox consists of two major components such as WiFi and Camera, in which the WiFi unit provides an ability to the SmartBox to communicate with the server unit to process the captured digital images and the Camera is used to capture the agricultural field plant leaf images in good manner. Both these functionalities are worked together to provide an efficient plant leaf disease identification mechanism in clear manner. The resulting section of this paper provides a clear view of the outcome with practical emulations.

2. Deep learning based classification strategy with WiFi interfacing

A deep learning procedure for processing the data or image is to train the machine based on the classification norms, in which it identifies the abnormal portion and the normal portion in clear manner by using modelling logic. The trained machine can easily cross-validate the testing data or image with proper comparisons done with respect to the models generated based on the training phase. The trained images are utilized on the comparison time of the real-time testing inputs and the proper outcome is generated with respect to the classification logic.

The accuracy levels are most important while processing such complex tasks in real-time manner. For this purpose a specialized classification filters are utilized over the proposed approach, in which it validates the input image acquired from the SmartBox with respect to the structure and clarity of the pixels. So, that the mismatched pixel ratios are identified and removed that from the actual scenario as well as producing the higher accuracy levels in good manner. In this paper an Intelligent Leaf Scanning Mechanism utilizes the logic of deep learning to analyze the plant leaf images in clear manner and producing the maximum accuracy levels over prediction of leaf diseases.

The following figure, Fig. 1 illustrates the process workflow diagram of the proposed deep learning model, in which the figure is initiated with the image processing logic. The images are acquired from the SmartBox data repository and forward that to the server unit with the help of WiFi enabled internet services. The acquired data is to be pre-processed with respect to the structure and the size of the images acquired. The feature extraction process analyzes the features presented into the pre-processed image and returns that to the server processing unit. The segmentation process extracts the background and foreground units of the image as well as the classification part extracts the affected portion and alert the farmers accordingly.

The WiFi interfacing associated with the SmartBox can directly accumulate the images from the image repository consists over the SmartBox and pass that to the remote server for processing, in which the remote server is maintained over this approach for preventing the unwanted data loss occurred over the local regions. This provision of WiFi based internet services allows the SmartBox to preserve the records safely over the remote medium with the provision of data monitoring based on timely manner.

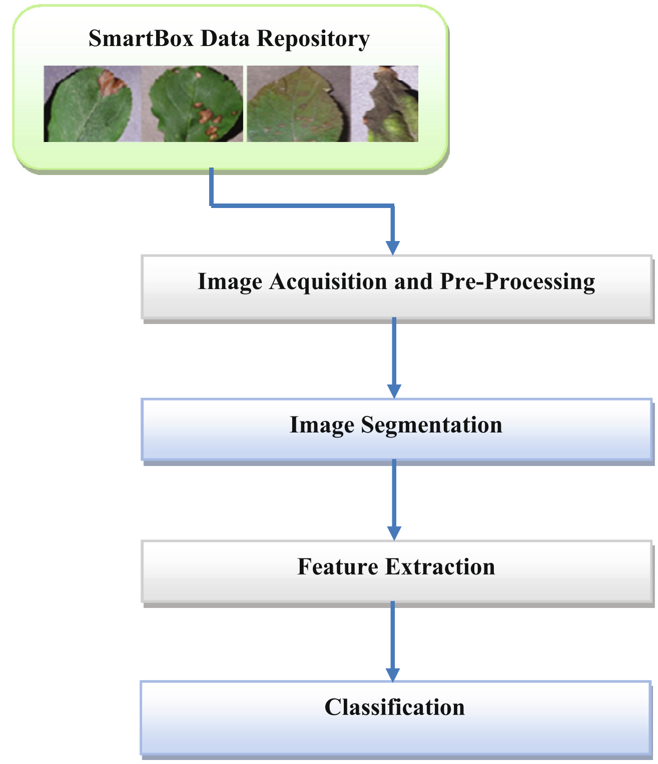


Fig. 1. Process flow diagram.

2.1. SmartBox

A SmartBox is a tool which integrates the components such as WiFi and the digital camera to monitor the agricultural field especially monitor the leaf structure of the plants to identify the diseases on initial stages to avoid overall farm land affection. Generally, a farmer suffers based on the late identification of disease spread over the crops. This is due to the lacking of time and efficiency of human, instead of doing such things, a smart lightweight device is introduced to monitor the crop fields in an intelligent manner with 24X7 alert support. This Smart Device is called as SmartBox, in which it provides a proper alert to the farmers if any leaf over the plant is getting affected.

This kind of SmartBox is required to place over the agricultural land on particular distance such as 10 feet ratio over the field to monitor the plants efficiently without any human intervention. The following figure, Fig. 2 illustrates the clear shows the view of SmartBox picture clarity and how the plant leaf images are captured by using the lightweight smart device. In this concern the term lightweight indicates the weight measure of the SmartBox, in which it has the weight measure of 1.05 kgs with the camera, WiFi, power modules and related accessories. This device requires the overall input power range of 12v DC power supply, in which the power value of 12v DC can easily be supplied from the battery source as well.

The SmartBox is operated with respect to the logic of Intelligent Leaf Scanning Mechanism (ILSM), in which it associates the deep learning principles as well as the classification logic to manipulate the images acquired from the data repository and identifies the diseases efficiently with proper specifications as well as alert the respective farmers with location and plant specifications.

The rest of this paper describe regarding Related Study over section 2, further section of Section 3 illustrates the proposed system methodologies in detail with proper algorithm flow and the Section 4 illustrates the Result and Discussion portion of the paper and the final section, Section 5 illustrates the concept of Conclusion and Future Scope of the proposed paper. These all will be explained in detail over the further section summaries.

Fig. 2. Leaf images captured by using SmartBox.

2.2. Related study

Shourav-Paul et al. [4] proposed a paper related to Apple Leaf Disease Prediction Using Machine Learning Algorithm called Multi Class Support Vector Classifier (SVM). In this paper [4], the authors described such as each year, black-rot as well as cedar-apple rust have reduced apple yields. It has a sizable impact mostly on the agriculture segment and the economy of the country. By integrating machine learning and information manipulation concepts, a method is proposed [4] for detecting diseases on contaminated apple leaves. This method is effective at classifying certain contaminated and non-contaminated apple plants. Preprocessing the image with the many image analysis, as well as the Adaptive threshold algorithm and histogram equalization, is the first step in the identification process. Using image segmentation, the infected area is separated, and a Multi class Support vector machine accurately recognizes the infection type from both the actual image database among 500 pictures. Additionally, it represents the frequency of the diseased apple plant's total affected region.

Sadia-Akter et al. [5] proposed a paper related to Identification of Potato plant Infection through Artificial Intelligence logic. In this paper [5], the authors described such as Potato is a major crop in Bangladesh. For several decades, potato production seems to have been extremely common in Bangladesh. However, distribution of food is being harmed by a number of diseases, which are rising farmers' costs. Even then, several vegetable pathogens are impeding potato production, increasing farmers' costs. This is causing havoc in the farmer's life. A autoimmune diseases detection process that automates the process of increasing potato production and digitizing the system and the primary objective is to determine potato infection using leaf images, which we will accomplish using innovative machine learning and artificial intelligence. This article [5] presents a picture of how potato leaf diseases can be detected and categorized using image processing and machine learning-based computer processes. The best method for detecting and evaluating these diseases is by image processing. The study divides over 2034 images of harmful vegetable and potato leaf from a publicly available plant town knowledge base and a well before prototypes are used to recognize and characterize sick and stable leaves. Among them, the software predicts with 99.23 percent accuracy in testing using 25 percentage test results and 75 percentage training data. This paper [5] results demonstrate that artificial intelligence outperforms all current tasks for detecting potato disease.

Xuan-Gao et al. [6] proposed a paper related to recognition of Plant Diseases Using Grown Leaves Using Double GAN. In this paper [6], the authors described such as leaves of the plant will be used to identify plant diseases effectively. The number of photographs of unhealthy leaves obtained from different plants, on the other hand, is often unbalanced. It is hard to ascertain diseases when the dataset is unbalanced. To balance such datasets, we used DoubleGAN to photorealistic detailed of unhealthy plant leaves. We suggested that we could use DoubleGAN to create significant images of harmful leaf with fewer samples by using it. DoubleGAN is a two-stage process. We used both safe and harmful leaves as inputs throughout stage 1. To begin, the pre trained model was constructed using the healthy leaf images as inputs to the Wasserstein generative adversarial network. The harmful leaves were used to create 64X64 pixel representations of desirable leaves using the pre trained model. Step 2 included the use of a super resolution deep convolutional framework to acquire equivalent 256X256 pixel images in order to balance the dataset. Finally, images produced by DCGAN were compared. With DoubleGAN, the dataset was extended; the produced images are more detailed than with DCGAN, as well as the specificity of tree species and infection identification reached 99.80 percent and 99.53 percent, respectively and the identification output is superior to that of the original dataset.

3. Proposed system methodologies

The proposed plant leaf disease detection scheme is completely novel in the sense of adopting latest technologies with powerful classification logics, in which the proposed approach utilizes the logic of deep learning with smart lightweight device called SmartBox. This SmartBox is operated with respect to the logic of Intelligent Leaf Scanning Mechanism (ILSM). The ILSM process the image acquired from the data repository found in SmartBox, in which the images are captured by using the camera interlinked with the

SmartBox as well as the WiFi unit allows the device to transfer the locally captured leaf images to the server unit. All the captured images are acquired by using the image processing mechanism with deep learning principles.

The deep learning procedure classifies the data with respect to the principles of Image Pre-Processing, Image Feature Extraction and Segmentation norms. The deep learning mechanism train the system with respect to the captured real-time images, in which the images acquired from the SmartBox is processed every time and use that image collection for the training purpose as well as the model is appended every time of new processing. At the time of testing each and every accumulated dataset model is considered to process and provide the exact predictions as a result without any intervention.

3.1. Image Pre-Processing

The camera captures photographs of the plant leaves and this picture is in the coloration of RGB format (Red, Green and Blue) format. After creating a color space mechanism for the RGB plant leaf image, a device-independent color space transformation is applied to the RGB color structure [1,7]. To remove noise from an image or to remove another component, various pre-processing techniques are considered. Clipping the image, that is cropping the color images to obtain the desired image field. The smoothing filter is used to smooth the image. The aim of image enhancement is to increase the contrast and the Red, Green and Blue based leaf images into grayscale images by the use of color transformation, which is represented by using the following equation.

$$C(x) \leftarrow \sum_{i=0}^{256} (RGB).(0.2989XR + 0.5870XG + 0.1114XB) \quad (1)$$

Where C(X) indicates the coloration of the captured leaf image and the image is then enhanced using contrast enhancement, which distributes the image's intensities. To distribute intensity values, the probability density function is used [2].

3.2. Feature extraction

Extraction of features is important for object recognition. Image processing is used in a variety of applications. Color, texture, morphology, and edges are all characteristics that can be used to identify plant diseases. Many researchers consider color, texture, and morphology as features for disease detection in their paper [3]. They discovered that the morphological outcome is superior to the other features. Texture refers to the distribution of color in an image, as well as the roughness and toughness of the picture as well as additionally, it can be used to detect contaminated plant areas. The feature extraction process of the proposed approach is designed with respect to the principles of deep learning mechanism as well as the image features are so important to identify the plant leaf diseases in correct manner. The following equations are used to extract the textural features of the image acquired from the SmartBox.

$$H_{Vector} \leftarrow \begin{cases} R, ifR > B, G, ThenR \\ G, ifG > B, R, ThenG \sum_{i=1}^{n} (\boldsymbol{RGB}) \boldsymbol{x}^{i} \boldsymbol{C}^{i+1} \\ B, ifB > R, G, ThenB \end{cases} \quad (2)$$

Where H_{Vector} indicates the Color of features extracted with respect to the vector distance. The color variations are the major cause to define the matrix based on the correlation of pixels as well as the proposed deep learning model associates the feature analysis process based on the logic of SmartBox digital images with the intensity of 1024X740 image pixel ratios. Until extracting the color from the background, the input plant leaf image features are enhanced using the entropy based technique to retain the detail in the affected pixels [8]. To differentiate the grape leaf from the non-grape leaf portion, the H and B features from the SmartBox in association with the color spaces and to identify the colors of disease leaves, a ILSM with multilayer perceptron is implemented.

3.3. Segmentation

Segmentation is the process of dividing an image into distinct sections with similar features or characteristics. Segmentation can be accomplished in a variety of ways, including the binarization' process, k-means clustering, and converting RGB images to HIS models. Segmentation through Boundary and Spot Detection methodology provides higher efficiency in order to attain multiple correlations between accuracy and performance improvements. For segmentation, the RGB image is converted to the HIS model. As described in [9], boundaries recognition and understanding of the topic assist in locating the infected portion of the leaf. To determine the boundary and the correlations of vectors is considered and a demarcation prediction model is used [9]. The Segmentation process is mainly considered here to extract the background from the input leaf image and process only the foreground portion of the image, so that the affected portions are easily classified with respect to the extracted features of the leaf image.

3.4. Classification

The proposed approach classification scheme is completely belongs to the deep learning approach, in which the smart lightweight device called SmartBox acquires the image from the agricultural field and maintain it into the data repository with the size of 1 TB maintained into the Smart Device. That memory adaptation allows the device to gather n number of leaf images instantly from the farm fields continuously with different variations. The images accumulated from the data repository are transmitted to the server unit with the help of WiFi unit connected into the SmartBox. The received leaf images on the server end are processed with respect to the specifications mentioned in previous summaries. The classification phase analyzes the leaf image with respect to the extracted features over the segmented foreground portion. The segmented portion clearly portray the affected region and the non-affected region in visual manner but the proposed Intelligent Leaf Scanning Mechanism (ILSM) analyze the details in clear manner and provides the proper classification summary with proper accuracy ranges.

4. Results and discussions

In this summary, the empirical analysis of proposed approach of deep learning based leaf disease identification and provide the proper alert summary to the farmers with the help of new lightweight smart device called SmartBox, in which it accumulates the digital images by means of camera associated with it as well as the captured digital leaf images to the server nit by means of integrated WiFi mechanism. The integrated WiFi mechanism provides the internet services to transfer the locally captured files into the remote server for manipulation. The server end receives the leaf image and creates a trained model with respect to the procedure of Deep Learning as well as the testing images will be further appended into the created model for future references. The server end handles the digital image processing scheme by means of Intelligent Leaf Scanning Mechanism, in which it analyzes the

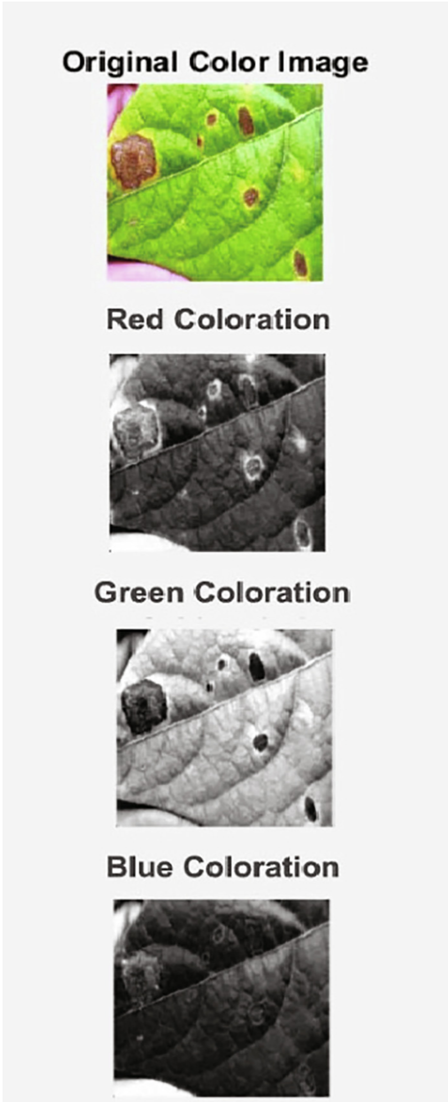
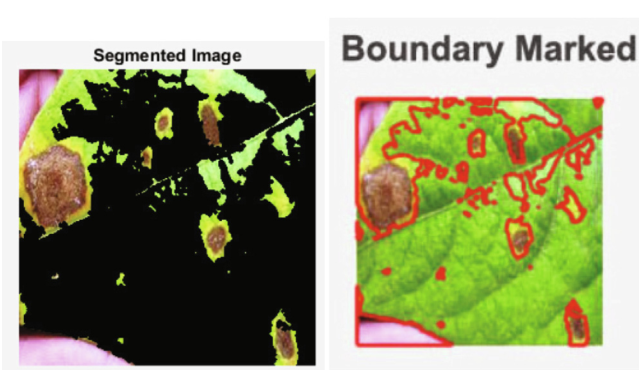


Fig. 3. Image acquisition and pre-processing.

input leaf image and provides the proper prediction summary. The following figure, Fig. 3 illustrates the logic of image acquisition and preprocessing natures in clear manner with graphical representations.



(a) (b)

Fig. 4. (a) Segmentation and (b) Boundary detection perception.

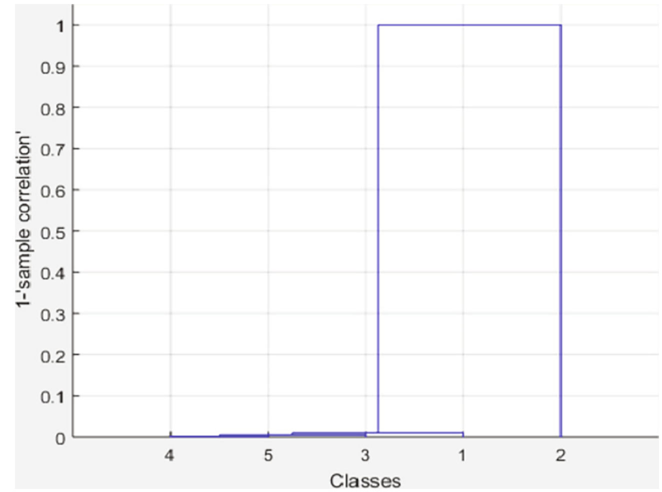


Fig. 5. Correlation matrix.

The following figure, Fig. 4 illustrates the bouundary detection of the affected leaf image and the regions are clearly visualized with the help of red color markings as well as the affected portions are clearly dictated with proper specifications. This process of boundary detedction is possible only segmenting the input image based on the background and foreground subtraction process. Once the background is eliminated from the input leaf image the outcome is easily segment the affected portion in clear manner and the following graphical perception shows that.

The following figure, Fig. 5 illustrates the correlation view of the proposed approach with respect to the graphical representations.

5. Conclusion and future scope

Accurate identification and classification of plant leaf diseases is critical for agriculture production and progress, which can be accomplished by digital image processing methodologies. This article addressed various strategies for segmenting the plant's diseased portion. Additionally, this article covered several feature extraction and classification techniques for extracting characteristics of infected leaves and classifying plant diseases. It is possible to efficiently use deep learning methods for disease classification in plants, such as self organizing feature maps and similar classification models. This paper utilizes the image processing techniques to reliably identify and classify different plant diseases using these tools. In this paper, a smart lightweight tool called SmartBox is introduced with the association of Intelligent Leaf Scanning Mechanism (ILSM) to accomplish the deep learning procedures to predict the disease accurately in fine manner.

In future the work can further be enhanced by means of adding some time efficient schemes with deep learning scheme to improve the training efficiency with less time constraints. By applying the time efficient algorithms to the proposed ILSM scheme, it will be improved in drastic manner and produce better results.

CRediT authorship contribution statement

U. Maheswaran: Formal analysis, Methodology, Supervision, Validation. **Ravindra Babu Kallam:** Writing - original draft. **B. Arathi:** Formal analysis, Writing - review & editing. **Koppula Prawan:** Formal analysis, Writing - review & editing. **G. Anitha:** Formal analysis, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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