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Plant Leaf Disease classification techniques using Leaf Images: A Study

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Abstract: Automatic Plant disease identification has become a major challenge in precision farming. In this research, an overview of the applications of computer vision techniques on the identification of Plant leaf disease is presented. This paper reviews the 28 research efforts that employ the most common artificial intelligence techniques related to plant leaf disease identification using leaf images. The techniques namely nearest neighbors, Support vector machine, Artificial neural network, and Convolutional neural network are illustrated and analyzed. Present challenges and opportunities of these techniques also highlighted. The review would help researchers to understand the applications of these techniques in plant disease detection.
Keywords: Artificial Intelligence, Artificial Neural Network, Back Propagation, Convolutional Neural Network, Deep Learning, K-Nearest Neighbors, Machine Learning, Plant Leaf Disease Identification, Support Vector Machine.

1. Introduction

Plant disease has become an important threat to the number of farming products. Primarily, the plant diseases are affected by bacteria, fungal and viruses [1]. It causes major losses in production and affects the quality of fruits, vegetables, and seeds. The plant leaf disease damages the photosynthetic system of the leaf and disturbs the plant health. Early plant disease detection techniques are essential to improve the sustainability of agro-ecosystems.

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The combination of increasing computing power and current developments in computer vision made possible through artificial intelligence has paved the approach for automatic plant disease detection and diagnosis [2]. Innovative imaging techniques to identify plant diseases using leaf images are discussed in this study. Examples of plant leaf diseases can be seen in Figure 1.

Figure 1: (a) Tomato early blight, (b) Strawberry leaf scorch, (c) Grape Black-rot, and (d) Peach bacterial spot

A number of artificial intelligence methodologies are presently used for solving leaf disease classification problems [3]. Some important methodologies are the nearest neighbor, support vector machine, neural network and convolutional neural network [1,2]. The data pre-processing approaches are used to improve the classification performance of these methodologies. All above-mentioned methodologies are separated into subsequent sections, starting with nearest neighbor algorithms for the plant leaf disease classification process. This article is structured as follows. Section 2 presents the K-Nearest Neighbors algorithm related works. Section 3 discusses the Support vector machine algorithms for plant disease identification. The Neural network algorithms based on plant disease identification techniques are given in section 4. Section 5 presents a survey of plant disease identification models using convolutional neural network algorithms. Finally, section 6 presents the conclusions of this survey.

2. K-Nearest Neighbors

K-Nearest Neighbors (K-NN) is a simple and extensively used non-parametric classification algorithm. K is the number of nearest neighbors, it is used to find the core in the K-NN algorithm. In [4], the authors proposed a K-NN classifier for brown spot and frog eye diseases classification in soybean plant using leaf images. The classification accuracy of the model for brown spot and frog eye diseases are 70% and 80% respectively. The authors in [5] presented a maize diseases recognition method based on K-nearest-neighbor using leaf images. On average, the recognition rate using this approach was 85%. Additionally, the identification of plant deficiency can be achieved using K-NN classifier. This technique was applied to grapevine plant potassium deficiency detection [6]. Another approach based on K-NN classifier for the identification of brown spot disease, leaf blast disease and bacterial blight disease in paddy plant leaf was suggested by the author in [7]. The testing accuracy using this method was 93.33%.

3. Support Vector Machine

A Support Vector Machine (SVM) is one of the supervised learning technique used for classification and regression problems distinct by a separating hyperplane that separate the two different classes. The authors in [8] proposed a model for identifying grape leaf diseases such as scab disease, rust disease, and no disease using SVM classification algorithm. Identification of cucumber leaf diseases using support vector machines. This technique was implemented using shape and texture features presented in [9]. Similar method that was recommended by the authors of [10] incorporates the features that are learned by the SVM algorithm with respect to the rice diseases using shape and color texture features. The overall accuracy of this method was 97.2%. The authors of [11] used the SVM classification algorithm for the identification of disease-causing agents in cotton crops. In [12], the authors proposed the SVM classification algorithm with a radial basis function for recognizing cucumber leaf diseases. The authors in [13] proposed a model for the identification of the diseased part of plant leaf and using the SVM algorithm with texture features. The overall classification accuracy using this approach was 94%.

Likewise, the detection of tomato leaves diseases using SVM algorithms with different kernel functions and 800 healthy and infected tomato leaves images. Overall, the classification accuracy of 99.83%, using the SVM with a linear kernel function and presented in [14]. In [15], the authors proposed a soybean disease recognition system using the SVM algorithm and image dataset with 1200 samples. Furthermore, the authors in [16] presented a classification model for plant disease using image SVM technique with color and texture features.

4. Artificial Neural Network

Artificial Neural Network (ANN) is also known as a neural network, one of the machine learning techniques mainly used for pattern reorganization problems. ANN consists of input, hidden and output layers. The hidden layer help to transform the input into the output layer. The authors in [17] proposed a model for detecting Phalaenopsis seedling diseases using ANN. The ANN with color and texture features were used to implement the model. The testing outcome of the model was 89.6%. In [18], the authors developed a similar ANN model for classification of plant leaf and stem diseases. The precision of the model was around 93%.

Similar approach that was implemented by the authors in [19] integrates the color features, shape features and texture features that are extracted by the radial basis function neural networks with respect to the wheat and grape plant diseases. The best classification accuracy of the model was 94.29%. In [20], the author proposed Palm Oil Leaf Disease detection model using the ANN technique. Overall classification accuracy of 87.75% using this technique. In [21], the authors developed a similar deep ANN technique for detection of wheat leaves disease using leaf images. Average testing accuracy of the model was 85 percent. Additionally, the Disease Classification and Severity Estimation can be achieved using ANN. This technique was implemented for Soybean plant [22] and achieved a classification accuracy of 93.3 %.

Back-propagation is fine-tuning the weights of a neural net based on the error rate achieved in the past iterations. In [23], the author proposed a Maize Disease classification model in Corn plant using the Back-Propagation Neural Network (BPNN) technique. The classification accuracy of the BPNN model was above 98%. In [24], the author proposed a grape leaf diseases classification model using the BPNN algorithm. Furthermore, the author in [25] presented a model for identifying three cotton leaf diseases using BPNN technique. The authors in [26] presented a BPNN algorithm for detecting Groundnut leaf disease using leaf image.

5. Convolutional Neural Network

A Convolutional Neural Network (CNN) is one of the most successful deep learning algorithm to solve computer vision problems. CNN requires much lower pre-processing as compared to other machine learning techniques [27]. Three important layers are used to build CNN model: Convolutional layer, Pooling layer, and Fully-connected layer. Convolutional layer extracts high-level features for instance edges, from the input image. Pooling layer reduces the spatial size of the convolved features from the convolutional layer. Finally, the fully-connected layer is the last layer of the CNN model, it learns non-linear function in that space. The sample architecture of the convolutional neural network can be seen in Figure 2.

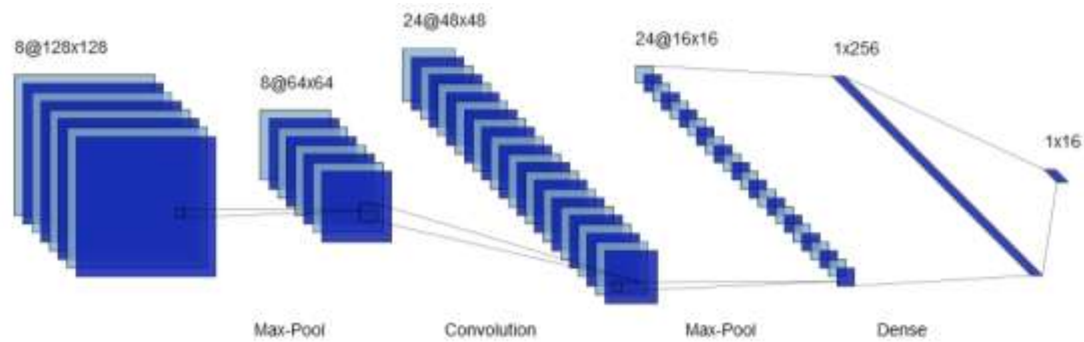

Figure 2: Sample architecture of CNN model

The authors of [28] used the CNN model and public dataset of 54,306 images for the detection of 14 different plants and 26 diseases and the testing performance of the model was 99.35%. In [29], the authors implemented the CNN model for categorizing thirteen different types of plant diseases. The authors in [30] recommended a model for detecting rice crop diseases. The CNN model and 500 natural images of rice leaves were used to develop the model. The model achieves the testing accuracy of 95.48%. Likewise, the identification of the tomato plant diseases and pests using CNN technique was proposed in [31]. Most recently, The CNN with An open database of 58 different classes and 87,848 images was developed in [32] for detecting the plant diseases. The model achieved 99.53% classification accuracy on 17,548 testing images.

6. Conclusion

In this paper, we have performed a survey of computer vision researches applied in the automatic plant disease identification challenges. We have identified 28 relevant research papers, examining the technical details of the algorithms employed and overall performance according to the performance metrics employed by each paper. We have then compared all the computer vision techniques such as nearest neighbors, Support vector machine, artificial neural network, and deep convolutional neural network in terms of performance. Our findings indicate that a deep convolutional neural network offers better performance and outperforms other state-of-art techniques in plant leaf disease identification problems. Our aim is that this survey would motivate more researchers to experiment with the deep convolutional neural network, applying it for solving various plant disease detection and diagnosis challenges.

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