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Applications of Machine Learning In Plant Disease Detection

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Abstract

Computerization in the field of agriculture is witnessing a great success in many agricultural aspects including detection of various plant diseases. Focus of almost every country has shifted towards the automation of agriculture to attain preciseness and accuracy and to serve the continuously increasing demand of food. Among the major challenges in agriculture, plant disease detection is a significant factor affecting the outcome of farming. Quality ofvegetables, fruits, legumes and grains is affected by plant disease, and heavy loss in production and subsequently economic loses are observed, so there is requirement of fast and effective plant disease detection and assessment methods. This paper explores the ways in which machine learning models can be applied to improve the process of plant disease detection in early stages to improve grain security and sustainability of agro-ecosystem.

1. Introduction

The process of agriculture starts from sowing of seeds to crop harvesting. During this major challenges influencing the overall production of the crop are disease infestation, management of storage, control of pesticides, identification of weed and management of weed, lack of appropriate soil and water management facilities etc. Artificial Intelligence and applications of machine learning have entered in these mentioned categories. AI technologies works on the basis of past learning experiences. Applications of techniques of Machine Learning (ML) or Deep Learning (DL) in the form of Back propagation, Artificial neural networks, Convolutional neural networks, are automating the machine work and developing advanced technologies. The loneobjective of ML is to feed a logical model (machine) with statistical data from past experiences to make precise and correct decisions. ML is a mathematical approach of building intelligent machines. On the basis of the data related to water stress, nutrient content, images of crops, climate and soil moisture content, AI aids in the prediction of the disease and its cure.

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Major threat to food security is the plant disease as it directly effects the crop yield and consequently decreases production quality of crop. Diagnosis of crop disease accurately and precisely is very challenging. Conventional system of plant disease identification rely on human intervention. Visual inspection of plants, past experience of farmer and his personal wit and intuitions are being used to detect plant diseases. Wrong judgements and delay in making correct decision adversely affect the productivity. But now a days human interventions have been combined and sometimes replaced with different technologies [1-2]. With the advancements in technologies, and cost reduction of image acquisition an array of image based diagnosis methods have come up. However an image enclosed very dense information so it becomes difficult for computer system to process it directly. Pre-processing of images to extract certain features like colour, shape is done prior to this. Algorithms of machine learning play their role here in this part. In an initial attempts to apply deep learning to detect plant disease from images is presented in 2016 which was used to train a model capable of classifying 14 different crops and more than 25 diseases with 99.35% accuracy [3]. After that many deep learning models are presented for crop disease identification [4-10].

2. Machine Learning Techniques

Machine learning provides computers the capability to learn without being explicitly programmed, very similar to working of a human being. Machine is learning from past experiences (which is actually fed in data) with respect to some classes of tasks, if the performance of task improves with more experience. Learning can be classified as

- Supervised
- Unsupervised
- Semi Supervised
- Reinforcement

Supervised learning refers to labelled dataset, consisting of both input and output parameter, for training the models. While training a model ration of training and testing data is kept 80:20. Supervised learning is further categorized as Classification and Regression. Classification comes under supervised way of learning tasks where output is a discrete value. This discrete value may be a binary value or multi classed. While regression is a supervised learning model which produce continuous value range. Aim of the regression is to predict a value closer to output value. Smaller is the error, greater is the accuracy. Examples of supervised learning models are Linear Regression, Nearest Neighbour, Gaussian Naive Bayes, Decision Trees, Support Vector Machine (SVM)and Random Forest.

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In unsupervised learning targets are not given to model to be trained so only input parameters are there and no output parameter is given to the model. Clustering and Association are two types of unsupervised learning. Clusteringis applied to data arranged in the form of groups created according to various patterns identified by model of machine. While a rule based technique to figure out relations among parameters of a large data set, is called Association. Examples of unsupervised learning models are K-Means Clustering, BIRCH – Balanced Iterative Reducing and Clustering using Hierarchies, DBSCAN – Density-Based Spatial Clustering of Applications with Noise, and Hierarchical Clustering.

Working of Semi supervised learning lies somewhere between above discussed techniques. This kind of learning is used while working on data some of which is labelled and some part is unlabelled. Unsupervised technique is used to calculate labels and then these calculated values are fed to supervised learning techniques. In image datasets where most of the images are not labelled, this technique is more popular.

In reinforcement learning, performance of the model keeps on improving with feedback to learn patterns and behaviour. Each time data is fed, it is learnt and added to knowledge which is training data. So, more it learns the better it get trained and hence experienced. Algorithm for reinforcement learning are Temporal Difference, Q-Learning and Deep Adversarial Networks. The entire taxonomy is presented in Figure 1.

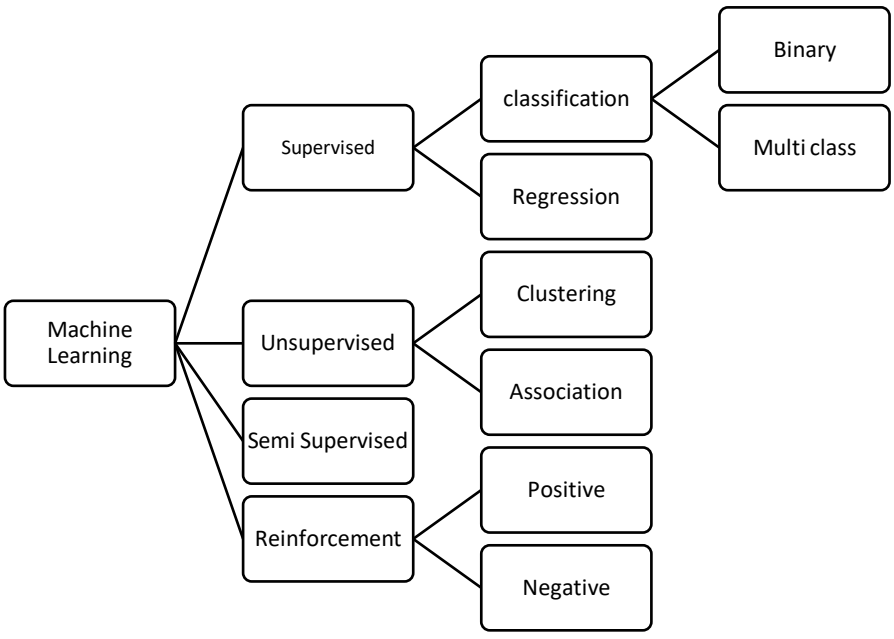

Figure 1: Taxonomy of Machine Learning Techniques

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In every kind of learning Dimensionality Reduction analysis is executed to get more compact and lower dimensional representation of dataset. Effect of dimensionality may be avoided by performing dimensionality reduction before applying regression or classification model. In order to avoid the effect of dimensionality, it isperformed before applying a classification or regression model. Principal ComponentAnalysis (PCA), partial least squares regression, and linear discriminant analysis are some common DR models.

3. Applications of ML in Disease Detection

Plant disease identification is a subject of serious concern to farmers as it directly predicts the yield and effects productivity. In order to identify a plant with some disease and recommending necessary moves of recovery,huge experience and expertise are required. To diagnose the disease and suggest control measure many computer aided systems are being used almost in every country. At very early stage, rule based systems were developed. A prototype of an expert system was proposed by Byod and Sunfor diagnosis of potato diseases [11]. The proposed prototype emulated human expertise in the diagnosis of potato plant disease according to the symptoms. Some other related work is seen for identification of plant disease [12, 13]. The knowledgebase consisted of knowledge about different diseases of a rice plant. Tilva et al., proposed a fuzzy logic based model toforecast diseases based on leaf wetness duration [14]. The system created utilized the knowledge of favourable climate conditions for various micro-organism responsible for diseases.

Artificial Neural Network (ANN) based model were also designed to control diseases in different crops. Francl and Panigrahi [15], created back propagation based ANN architecture to detect wetness in wheat leaves.Babu and Rao [16]used back propagation neural networks in their leaves recognition system for pest and disease control on crops, Ismail et al.[17] created an Intelligent system for tea leaf disease detection, Karmokar et al. [18], Sladojevic [19], Hanson et al. [20]and Hahn et al. [21] worked in the same patterns to identify diseases using ANN. Some hybrid systems were alsosuggested. Huang proposed an image processing modelcoupled with artificial neural network model to classifyphalanopsis seedling diseases [22]. Sannakki et al., enforced afuzzy logic approach coupled with image processing todetected percentage of infection in leaf [23]. A system usingk-means segmentation algorithm was developed by Al-Hiary,et al. [24] and Bashish et al. [25]. Dr. Wheat is a web basedexpert system developed by Khan et al., for diagnosis ofwheat diseases [26].

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4. Tools and Techniques

Plant diseases may be caused by bacteria, fungus, nematodes, viruses, pests, weeds, insects, photo plasma and other pathogens. Farmers on regular inspections can identify signs and symptoms of condition of plant. Signs may be in the form of ooze, a cottony mass or a blank mass on the plant. Symptoms include galls, wilt, rots, cankers, necrosis, chlorosis as well as underdevelopment and overdevelopment. Certain mobile apps consider these signs and symptoms and prescribe recovery solutions on the basis of that.

CropDiagnosis

The main aim of CropDiagnosis mobile app is to develop decisions for pest management with accurate crop diagnosis and personalised instructions by application assistance. Crop details are gathered including type, location, soil etc. and provided through an easy interface in the form of a smart questionnaire. Some other characteristics like type of the crop, appearance and growth are also fed and most likely diagnosis is made. The app requires information details of characteristics of cultivation such as type, location, soil and characteristics like appearance, type, and growth of plant in order to make any decisions.

Plantix App

Along with some other features, key feature of Plantix app is to detect plant diseases. Plantix App is developed by an agricultural tech startup PEAT in Berlin. It is used for detecting defects and deficiencies in soil. App makes use of images of plants to identify diseases. Collection of such images is kept in smart phone and are matched with image in server for diagnosis. Significant feature of Plantix app is the automated crop disease identification. App diagnoses is done on the basis of images uploaded by farmers of their infected plants. Apart from identification of disease, app also suggest measures to diminish disease and gives useful information on prevention of crop disease in next season. App also keeps repository of diseases so that farmers with no internet connectivity can also refer to it.

SaillogAgrio

Saillog is an AI based solution to help farmers in detecting and treating crop diseases and pests. Agrio is an interactive mobile phone application encompassed by Saillog and is free of cost. Users of this app clicks photograph of infected plants and uploads them through a smart phone. These images are then analysed and automatic detection of diseases is carried out. Sometimes immediate solution is also available. It makes use of AI techniques and provides single complete solutions to different problems of disease and pest management. Its AI engine is capable of identifying hundreds of diseases and defects.

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5. Conclusion

Applications of machine learning and deep learning in the field of agriculture is gaining momentum. Techniques of image processing are used for accurate detection and classification of crop disease and the accurate detection and classification of the plant diseaseis very important for the fruitful cultivation of crop.Number of commercially available products are becoming popular day by day to detect plant diseases and identify recovery solutions and assist farmers in improving their crop productivity and subsequently profits.

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