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A REVIEW ON ADVANCED CROP IMAGE ANALYSIS AND CLASSIFICATION USING MACHINE LEARNING AND DEEP LEARNING APPROACHES FOR AGRICULTURE

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Abstract: Agriculture is the primary income source of Indian economy, and primary source of livelihood in the world. The quantity and quality of crops are reduced due to plant disease and pests in agriculture. So, detection of pests and disease are very important in the agriculture field to improve the quality and quantity of crop. This paper represents the transformation of role of advanced Machine Learning and Deep Learning Technologies for crop image Analysis and Classification in Agriculture. Machine Learning and Deep Learning technologies such as Convolutional Neural Network, Artificial Neural Networks algorithms etc. has shown amazing progress in predicting the images, classifications of images, analysis of images, and to improve the plant disease identification. K-Nearest Neighbour (KNN), Probabilistic Neural Network (PNN), Support Vector Machine (SVM), Artificial Neural Network (ANN), Genetic Algorithm, Fuzzy logic are the few Machine Learning algorithms for image analysis and classification.

***Index Terms* - Agriculture, Convolutional Neural Network, Deep Learning, Image Classification, Machine Learning.**

I. INTRODUCTION

The new farming techniques were elementary, dictated largely by fundamental knowledge of seed propagation, water requirements and seasonal cycles. In the 21^{st} century a significant change from traditional to digital farming began, introducing the **"precision agriculture"** into the world. Precision agriculture influences progressions in Information and Communication Technology, combining GPS, Remote Sensing, and Big Data analytics to improve yield and reduce environmental impact. This digital transformation facilitates the collection and processing of real time data on various factors such as soil conditions, crop health, weather patterns and pest infiltration, unpredictability of climatic conditions and variable soil fertility. An agricultural monitoring system can be defined as a suite of tools and methodologies designed to analyse, and report on various parameters within in the agriculture environment. These parameters may include soil properties, crop health, pest activities and farming practices. The system typically consists of analytical software for data processing and interpretation. Analytical software often authorized by artificial intelligence, machine learning, deep learning algorithms. Agriculture management systems, on the other hand, are operational frameworks designed to optimize productivity and profitability. These systems incorporate the technology to plan, organize and control agricultural operations. These operations include selecting suitable crops and making decisions about planting, fertilizing and irrigation strategies to managing pests and diseases [1]. Plant diseases posture a significant threat to global food security, causing losses of crop yields annually. The identification of plant diseases is crucial in agriculture, and it is essential for the development of smart farming applications [2].

Early detection and accurate identification of plant diseases are essential for effective disease management and control. Traditional methods of plant disease detection involve visual inspections by experts, which can be time consuming and often subject to human error. The use of smart agriculture techniques can provide a major boost to the economy of any country. With progressions in technology, Artificial Intelligence, Machine Learning and Deep Learning have emerged as promising solutions for automating and improving plant disease identification which can help prevent disease at early stage. Image analysis is an important research area in agriculture that can help in identifying and classifying diseases. Popular classification techniques like Artificial Neural Networks, Support Vector Machines, K-NN, Convolutional Neural Networks and Regression Analysis can be used to identify diseases from agricultural data. Convolutional neural network architecture enhances the classification accuracy of leaf diseases, machine learning techniques are used for the detection of crop leaf diseases. Enhanced k-nearest neighbour classifier is used for precise detection of crop leaf diseases [3]. Deep learning methods such as 2-D Convolutional Neural Network and 3-D Convolutional Neural Network have been widely used recently for hyperspectral image classification [4]. One specific technique that has proven to be effective is transfer learning supported by Convolutional Neural Network. Transfer learning allows models to leverage what they have previously learned to improve their performance. Convolutional Neural Network can be used to identify plant diseases by analysing plant images [5]. Deep learning models can be analyse satellite or drone imagery to detect crop diseases across vast expanses of farmland. Deep learning-based disease identification is a component of precision agriculture [6].

The Deep Learning algorithm is used for plant disease recognition and classification problems. Using continuous image capturing the autonomous agriculture vehicles accurately locate psychopathological problem in large cultivation field. The success of Machine learning is train and algorithm by access the large amount of data graphics processing unit (GPU) provides high computation power to achieve the parallelism in data computing [7]. Artificial Neural Network (ANN) is a mathematical model that is driven by the functional feature of biological neural networks. A neural network contains an interconnected set of artificial neurons, and it processes information using a connectionist from to computation. Deep learning is an AI science that imitates the working of the human brain in data processing and production of patterns for use in decision making. Deep learning is a subset of machine learning in artificial intelligence that has networks of learning skills from uneducated or unstructured data. Convolutional Neural Networks which are inspired by human visual system are like classic neural networks. This architecture has been particularly designed based on the explicit assumption that raw data are two dimensional that enables us to encode certain properties and to reduce the number of hyper parameters [8].

In plant disease detection, the most popular algorithms used for identifying diseases from plants are Machine Learning (ML) and Deep Learning (DL) classifiers due to their various advantages. Machine Learning is an important subset of Artificial Intelligence that refers to different mathematical algorithms. the purpose of Machine Learning is to learn and analyse the data to make decisions. Deep Learning achieved significant results in various applications, in particular image processing. Machine Learning has the five algorithms for classification and analysis of crop, such as Random Forest (RF), Support Vector Machine (SVM), Decision Trees (DT), naïve Bayes (NB), and K – Nearest neighbours (KNN) to detect leaf diseases. Deep Leaning has the Dense Net 201, VGG19, Mobile Net, Xception, and Inception [9]. K- Means Clustering is used to segmentation purpose and extracting the texture features of leaf's using Gay Level Co-Occurrence Matrix with features extracted in the form of energy, contrast, correlation, and homogeneity [10]. Deep Convolutional models have recently gained popularity as a method of picture classification for variety of agricultural issues, including the detection of plant illnesses, the identification of weeds the counting fruits, etc. Deep Learning is based on neural networks that can learn and employ strategies to make wise decisions [11]. Convolutional Neural Network architectures have been finely tuned and developed in recent years to allow the reuse of transfer learning. Amongst the popular and successful Convolutional Neural Network architectures are AlexNet, Visual Geometry Group (VGG), GoogleNet, Inception, and ResNet [12].

Deep Learning, a division of Machine of Learning, uses a hierarchical level of Artificial Neural Networks to perform the Machine Learning process. Artificial Neural Networks are built like the human brain, with nerve nodes linked together like the Internet. While traditional programs are built to perform analysis with data in a linear fashion, the hierarchical mission of Deep Learning systems allows machines to process data using a non-linear approach [13].

II. LITERATURE REVIEW

Laha, Suprava Ranjan et al., [2] deployed sensor networks, used pre-processed techniques, leveraging transfer learning, and incorporated explainable AI. Using these techniques, they improve the accuracy, scalability, and intractability of the ML models, enabling framers and algorithms to take proactive measures to prevent the spread of diseases, protect crops, and maximize yields. The authors used Support Vector Machine (SVM) technique for plant disease identification, and Convolutional Neural Network (CNN) technique for extracting features of images and analyse the image data. They collected the data from sensor networks.

Daneshwari Ashok Noola, Dayananda Rangapura Basavaraju, [3] in this the authors used EKNN classifier. It is evaluated considering the various traditional mechanisms and existing mechanism. This proposed model achieved massive value of accuracy, sensitivity, specificity, and AUC of 99.86, 99.60, 99.88, and 99.75 respectively. The future work is comparison analysis on in terms of precision, recall and f1 score. In this experiment they took the Plant village dataset.

Nizom Farmonov, Khilola Amankulova eț al., [4] the authors examined the wavelet attention 2-D-CNN on DESIS image classification for crop-type classification taking into account image dimension reduction and spectral AM. By using FA and Wavelet attention to diminish the size of the HIS, they successfully filtered out useless information in the low frequency domain. A 48 X 48 spatial patch was found the best on the HSI dataset and FA from 2 to 3 gave the highest OA. The result proved that the newly developed WA-CNN for crop type mapping can incorporate the specific details of features in the high frequency domain, improving CNN’s capacity to learn features of image categorization. A DESIS HS library was established for four major crops such as hybrid corn, sunflower, wheat, and soybean. They used DESIS dataset and SVM, CNN algorithms.

Orlando Iparraguirre-Villanueva, Victor Guevara-Ponce eț aļ [5] used 3 CNN models such as DenseNet-201, ResNet-50, and Inception-v3. They demonstrated an effective and promising approach, being able to learn relevant features from the images and classified them accurately. A dataset contains more than 87 thousand images of healthy and diseases crop leaves, categorized into 38 different categories was used. For the purpose of identifying and classifying crop plant diseases, they used CNN with transfer learning. The future work is to implement this experiment in the mobile application.

Punith Kumar, Dr. H. N. Champa [6]. In this the authors used DCGAN to provide data that closely resembles real images to increase the samples for training big neural networks and to increase the diversity and ability of detection models to generalize. They obtained the best results utilized to train the CNN network that they built by merging DCGAN with inception v3 model, where augmented and actual data were blended as input of the CNN. They founded a solution to the CNN network’s difficulty in converging, which was caused by the challenging data gathering and striking similarity of characteristics. Future work is they intended to find a better data augmentation approach to recognize tomato leaf disease. In this experiment the authors were used the dataset of diseased tomato leaves, which contains 2700 photos divided into 3 classes and all have the same resolution of 224x224 pixels. This dataset was produced in such a way that, in each class 50% of the images from publicly available dataset is mixed with 50% of the images which are captured manually in the farm field.

In S. Poornam, A. Francis Saviour Devaraj [7], the authors used Deep Learning techniques to disease detection and classification. The Network is trained by Caffenet deep learning framework. Convolutional Neural Network is trained with ReLu. The pretrained model of Convolutional Neural Network used transfer learning. The convolution base of Convolutional Neural Network generates features from image through the convolution and pooling layers. The classifier part of the Convolutional Neural Network classifies the image based on the features extracted from the convolutional base.

Sara Belattar, Otman Abdoun et al, [9] compared different deep learning and machine learning algorithms to specify the best classifier for early detection of mint plant disease namely: Dense Net 201, VGG 16, Xception, Mobile Net, Inception-v3, Support Vector Machine, RF, LoR, KNN and DT. The experimental tests showed that the Deep Learning classifier performed well in comparison with the Machine Learning classifiers in all performance measures used. Dense Net 201 is the best classifier, with an accuracy of 94.12%, DT is the worst, with an accuracy 61.76%. They gathered the dataset manually using an iPhone 7, which contains both unhealthy mints and healthy mints.

Sara Belattar, Otman Abdoun et al, [10]. The experiment successfully made an application to cluster leaf diseases in rice plants into 3 cluster symptoms, namely bacterial leaf blight disease, brown spot disease, and normal. Applications made indicate the level of accuracy reaches a maximum value. Future work is applications created are limited only limited to clustering. Detailed explanations need to be added a additional information on each leaf disease in rice plants.

In Ihsanuddin, Eka Wahyu Hidayat et al, [11], the authors used the pre trained deep convolutional neural networks such as VGG-16, ResNet-50, InceptionV3 for leaf disease identification. They collected the data from online and on the playing filed. The data set contains the 4 categories of images those were Blast, Leaf Blight, Brown spot and healthy plant images. For testing purpose, they selected 50 photographs at random from the training set of each class. They got the experimental results like bellow.

Vi Nguyen Thanh Le, Selam Ahderom and Kamal Alame [12]. In this experiment the authors compared the performances of selected Convolutional Neural Network (CNN) models such as VGG-16, VGG-19, ResNet-50, and InceptionV3 with the k-FLBPCM algorithm. They identified the crop and weed species of similar morphologies. They used the bccr-segset laboratory data set for experimental results. The k-FLBPCM method achieved classification accuracies close to 99%. In this experiment the data set contains 30,000 images.

In Mahmoud A. Alajrami, Samy S. Abu-Naser [13], the authors proposed a solution to determine the type of tomatoes more accurately. They developed a model using Convolutional Neural Network, trained, validated, and tested it. The authors collected the tomato data set from the Kaggle. The data set contain the 3950 images, and seven classes. The image size in the data set is 150 x 150.

III. CONCLUSION

The advancement of machine learning and deep learning technologies has significantly transformed the landscape of crop image analysis and classification in agriculture. With agriculture being a vital component of the global economy, the need to enhance crop quality and quantity by addressing issues such as plant diseases and pests becomes paramount. This review explored various machine learning and deep learning approaches employed in the detection and classification of crop diseases, ultimately contributing to the improvement of smart farming applications.

The shift from traditional to digital farming, known as precision agriculture, has been facilitated by the integration of information and communication technology, GPS, remote sensing, and big data analytics. These technologies enable real-time data collection and processing, allowing farmers to make informed decisions regarding soil conditions, crop health, weather patterns, and pest activities. The implementation of agricultural monitoring systems, coupled with analytical software powered by artificial intelligence, machine learning, and deep learning algorithms, has proven crucial for optimizing productivity and profitability in agriculture.

Plant diseases pose a significant threat to global food security, causing substantial losses in crop yields annually. Traditional methods of disease detection, relying on visual inspections by experts, are time-consuming and prone to human error. The adoption of smart agriculture techniques, powered by artificial intelligence, machine learning, and deep learning, offers a promising solution. Notably, convolutional neural networks (CNNs), artificial neural networks (ANNs), support vector machines (SVMs), and other machine learning algorithms have demonstrated remarkable success in image analysis and classification for identifying crop diseases.

The literature review highlighted several studies that employed a variety of techniques, including transfer learning, wavelet attention, and deep convolutional neural networks, for crop disease identification and classification. These studies utilized diverse datasets, such as sensor networks, DESIS images, and manually collected datasets, showcasing the versatility of these approaches across different agricultural scenarios. Additionally, experiments comparing the performance of various machine learning and deep learning models consistently emphasized the effectiveness of deep learning techniques, especially CNNs, for accurate and efficient crop disease detection.

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