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Detection of Pathogens:A Comprehensive Study to Improve the Precision Agriculture

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Abstract— For human livelihood, agriculture is an extremely important sector in Indian Agronomy. Environmental toxic farm impact affects all fields, making it difficult to manage numerous challenging situations. In order to get benefited of a crop for farmers and end user's point of view, agriculture must adapt different technologies according to the day to day life environmental changes. Early identification of crop diseases will help farmers instead of entering into dangerous life threatening situations. For finding crop diseases along with close observation of a farmer, computer technologies will help a lot to maintain sustainable and healthy crop. Among several computing technologies, Deep Learning techniques create a major impact.In this paper we review various existing methods including machine learning, deep learning and AI for precision agriculture. The research insights provide understanding of state-of-the-art techniques, their limitations and the research gaps for further investigation towards precision agriculture.

Keywords- Deep Learning, ResNet50, Xception Algorithm, Leaf Disease Detection.

I. INTRODUCTION

India is an agrarian country. The agriculture sector in India remains the backbone of society, having employability approximately 58% of the population of India. In agriculture, numerous plant species are going to extinct due to global warming and many more reasons like deforestation etc. in recent years. Food production is the crucial factor for the livelihood of population. According to Agriculture Global Market 2023, the global population is intensifying and is anticipated to extend 10 billion people by the year 2050. Therefore, the production of high-quality, disease-free crops are placing a biggest role for the betterment of nation's healthy population and economy. Crop growth with effective cultivation is the main important factor forfarmers in their financial and social livelihood. To achieve the healthy crop, we must safeguard plants from diseases [1].

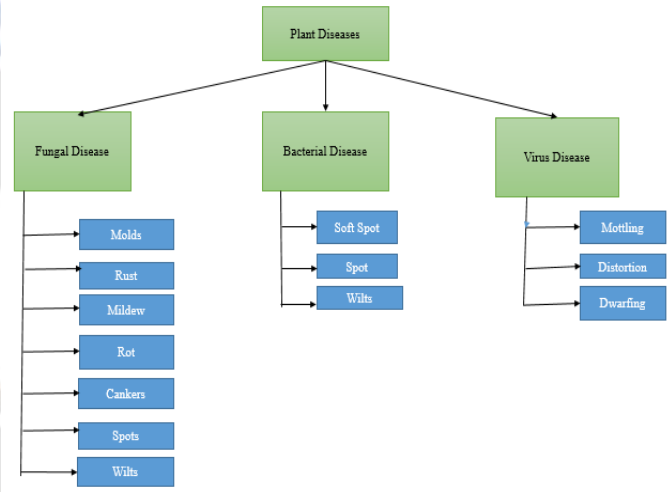

Figure 1. Different types of plant disease

Different types of plant diseases like **Bacterial diseases** such as aster yellows, bacterial wilt, blight, fire blight, rice bacterial blight, canker, crown gall, basal rot, scab, **Fungal diseases** such as rust, powdery mildew, black spot and **Viral diseases such as** curly top, mosaic, psorosis, spotted wilt etc. which will affect the plant growth are shown in figure1. The crop loss in agriculture will create a loss of eco-system. These diseases damage the crops which cause the huge loss for farmers economically

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per year. The below figure2 estimated crop losses due to plant diseases based on the survey of several farming studies taken from various literature studies [2], which have considered for various Indian states from the year 2015 to 2022 [2]. Values were derived using historical cause-of-loss data from the Indian Department of Agriculture Risk Management Agency.

These diseases damage the plants and make it useless which directly impact on the economyand income of the population. We all know that declining incomes, rotting harvests, and unsold goods directly affect the GDP rate. It also keeps the life of farmer threatening so the close monitoring at various phases of crop is therefore necessary. However, in earlier times, plant disease identification required simple naked-eye observation but these techniques were inefficient and inaccurate, so we involve computer technologies to identify the disease in early stages [2].

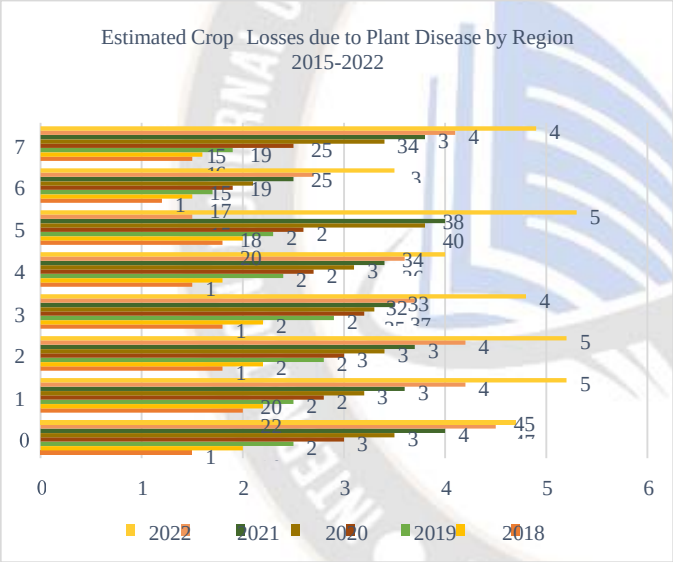

Figure 2. Estimates Crop Losses due to Plant Disease by Region 2015-2022

In order to accurately identify a healthy crop, automatic ratification and classification fordifferent stages of crop required. We are going to propose the model which will identify the diseased leaves with their cause as well as also tell the percentage of healthy parts of that leaf.

Due to the huge loss of crop, many researchers work on disease diagnosis and prognosis in plant. Along with continuous observation of farmers' recent computer technologies can also be helpful to anticipate plant disease in prior and will save the crop before get infected [3]. DL (Deep Learning) is more advanced and attested technology that is capable to predict the disease of the leaf with which it is infected with in early stages. Widely used techniques involve CNN (Convolution Neural Network) and ANN (Artificial Neural Network) both are capable to handlethe complex relation within the data. As huge datasets are available that one can train the model to behave like human by giving the patterns, structure and functioning of the human brain. Deep Learning algorithms such as Convolution Neural Network (CNN), ResNet50, etc. are widely used in identifying the image of the satellites, medical image processing, series forecasting, disease detection and anomaly detection. It processes the data by transferring it through many layers and extracting some features that exhibit convolution operations [4].

With the extent of this research the new techniques of Deep learning which involves network in the training part where the features of the mages are deeply focused on the pixels [5] which targets to the deep belief of the network which is named as [6] Deep belief Network (DBN). This technique tends to improve the accuracy of the model by utilizing the fine – tuning of the prunes [6]. Still many researchers involve in combining the many models together to improve the performance metrics of the overall system. By combining the two techniques together the model can overcome overfitting of the unseen pixels of the image [7].

The automation technology has brought massive changes in the technology which breaks through the hurdles in the production of crop [8]. The major changes in the technology have done to improvise the feature extraction of the image which is majorly express the characteristics of the image. Herein Deep learning techniques were brought into implementation [9] [10] to train the images depending on their pixels. The complete process is done computationally using CNN layers [11]. Slowly the researchers interest grabbed towards the transfer learning models with the amalgamation of the DensNet [12], Inception [13]. With this learning aid the problems can be solved precisely. This implementation is leading to another problem of augmentation which will increase the size of the system [14] [15]. This survey highlights the researcher's vision and their possible solution to the problems identified but there are still many unsolved problems which can be overcome by the limitations and providepotential solution [16] [17].

II. LITERATURE SURVEY

This section reviews literature on different methods and models used for agricultural crop monitoring, crop health and other data analytic.

A. Different Approaches: Learning Based and Technology- Driven Agriculture

In 2019, Marko Arsenovic et al. [18] conducted an analysis with a huge dataset where images of different leaves with different texture, different angles and all the weather conditions are considered in the dataset. There are two approaches by the author, one is traditional augmentation and the other is GAN based data. The major focus is on the AlexNet, VGG, DenseNet and ResNet. These two approaches include the syntactic data and training of GAN. This trained model gained an accuracy of 93.6% with complex surroundings. In future Scope, the work can be extended with the application that supports android as well as Mac OS where it will be easy for the farmer to detect the leaf disease in early stages.

In 2020, S.J. Grace Shoba et al. [19], proposed an automated approach for the plant leaf disease detection project is designed to detect whether the plant is affected by the disease or not and also to detect, by which type of disease the plant is affected. For this they have used a technique named Radial Basis Function Neural Network (BRBFNN). In future, this system shallbe implemented in agricultural crop fields and that will facilitate the monitoring of plants and updates the status by the name of the disease and if it is not affected by the disease, it updates ashealthy Leaf.

Punam Bedi et al. [20] in 2021, has given a novel amalgamation of automatic detection of plant disease identification where DL techniques like CAE (Convolutional Autoencoder) network & CNN (Convolutional Neural Network) which achieves an accuracy score of 98.38% where 9,914 training parameters are considered. In future we can work with more different variety of plant leaves.

In 2021, P. Kumari and K. Thulasimani [21] has done their first trail on Residual Network-50 model where the Rectified Linear Unit (ReLU) activation work was changed to Leaky- Rectified Linear Unit (Leaky-ReLU) where the part size of the layers of CNN are partitioned into 11x11 for investigation. The reason for this methodology is to decrease the effect of ReLU inactivation and improve the organization execution to some degree by upgrading the capacity to catch point by point highlights with accuracy 97.56%. In future we can extent this model with more dataset.

In 2021, Rashmi N et al [22] have developed the algorithm to identify the diseases in crops like potato, tomato, corn and grapes. They mainly used CNN algorithm for the disease classification. The overall efficiency achieved in disease detection is 97% using CNN. After the identification of the disease, recommending the pesticide for the diseased leaf is the main solution to the farmers. The extension of this work can be considering all the surrounding parameters like humidity, pH, rainfall, N, P, K values so that we can increase the productivity as more expected from the farmers.

Ng, Hui Fuang et al. [23] in 2021, the author focused on Mobile based application for identifying and classifying the grape leaf disease using DL. This app uses the Faster R-CNN which stands for (Recurrent Convolution Neural Network) with Inception-V2 spot detection to detect and centralize the dataset for the diseased area in the image. This proposed model is used to design and run the standalone application of a smartphone. This experiment on the grape leaf dataset gives the high accuracy on identifying the common types in grape leaf disease with high accuracy of 97.9%. The future scope can be this model should be made that capable to detect the crop disease of all types not only grapes.

In 2022, Rabbia Mahumet al. [24] proposed a technology which automatically detect the disease in potato leaves. The classification and identification of this model done on five classes where the classification is done like this: Potato Healthy, Potato Late Blight, Potato Early Blight, Potato Leaf Roll, and Potato Verticillium_wilt. This model ids developed based ion efficient DenseNet, which re-weighs the entropy of the loss function which cope with challenges that may imbalance the dataset. Further, the model gives the accuracy of 97.2% which can perform the extra layer of transition. The author provides the future scope of his workin such manner that certain modifications can be done in the architecture for many other leaves.

Hamoud Alshammari et al.in 2022 [25] this author presents a pre-eminent DL techniquewhich is used to classify the olive leaf where three DL models adapted with the GA version where the author mainly aims to find an optimal batch size number and epochs number to maximize and minimize the time required to respond with the guarantee high accuracy score. The model which achieves higher accuracy is the DenseNet model with the accuracy score of 98% with respect to binary classification. In the future scope the work that can be carried out is to collect different images of the olive disease where the samples are trained on a larger database to achieve more accuracy score.

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TABLE I PERFORMANCE OF DIFFERENT TECHNIQUES AND THEIR FINDINGS

References	Year	Methodology	Accuracy (%)	Findings
[1]	2011	K-means andNeural Networks	93.35	Leaf disease detection
[2]	2015	K-means clustering with Neural Networks (NNs)had been implemented forclustering and classificatio n of diseases that effect onplant leaves	82.9	Proposed Algorithm was tested on five diseases which influence on the plants;they are: ashen mold, Cottony mold,early scorch, late scorch, tiny whiteness
[3]	2019	Deep Convoluti onal Encoder Network	73.5	Seasonal Crops Disease Prediction and Classification
[18]	2019	Deep Learning	93.6	Plant Disease Detection
[19]	2020	Radial Basis Function Neural Network, SVM,FCM	95.89	Plant Disease Detection
[20]	2021	Deep Learning techniques Such as Convoluti onal Neural Network (CNN)and Convolution al Autoencode r(CAE)	98.38	Plant Disease Detection
[21]	2021	GLCM, Leaky ReLU, Deep Residual Network	97.56	Crop Disease Detection
[22]	2021	AI, Convolutio nal Neural Network, Random Forest, humidity, ph, rainfall, N, P, K	97	Identify the Diseases in crops like potato, tomato, corn and grapes.
[23]	2021	Deep Learning	97.9	A mobile application for detection and classification of grape leaf disease using deep learning
[25]	2022	Optimal Deep Learning basedon Adaptive Genetic Algorithm	98	Olive Disease Diagnosis
[26]	2022	Deep Learning Techniques	96.73	Tomato Leaf Disease Detection
[27]	2023	Transfer Learning-Based Convolutio nal Neural Networks	99.2	Smart Detection of Tomato Leaf Diseases
[28]	2023	Entropy-ELM with Whale Optimization Algorithm	99.8	Mango Pest Detection

Most recent research on technology-driven agriculture provides valuable insights. This section throws light on the most recent findings in the literature. With the emergence of IoT technology and AI, there are increasing efforts of their use towards precision agriculture.

AI enabled approach for disease detection Apple crop is explored by Al-Wesabi et al. [29]. They proposed a technique based on AI that involves Gaussian filtering, orientation-based data augmentation and efficient noise removal in visual inputs. Their methodology includes design of a novel deep learning technique known as CapsNet that exploits different optimizations such as hyper parameter optimization and water wave optimization besides feature extraction approach. Their method also exploits bi- directional variant of LSTM for disease classification. Specific limitation of the method in [29] is that it has no provision to capture live data from agricultural crop. Towards, this end their methodology

needs IoT integration where imaging sensors could capture crop details live for continuous crop monitoring.

Amandeep Singh et al. [30] in 2023, proposed a smart farming system based on AI and IoT. It was designed to realize a smart hydroponics farming for user-friendly approach in crop monitoring. Their work also includes a mobile application that is used for ease of crop monitoring. Their sensor devices are controlled by Raspberry Pi processor. In addition to the hardware components, a deep CNN model is used for disease prediction. The mobile application is used by farmers to conveniently observe crop requirements. However, the method in [30] has certain drawbacks. First, it has no optimization methods. Second, this method is based on deep CNN which could be combined with other deep models with a hybrid approach for further improvement in the crop monitoring dynamics.

Deep learning-based methods in precision agriculture are found more effective than their predecessors. Accordingly, Coulibaly et al. [31] in 2022 explored various deep learning models for taking precision agriculture further. Their research focused on recent advances in communication technologies to investigate on precision agriculture. Apart from these insights, their research found significant scope for future work. There is need for development of predictive models combined with visual transformation, need for advanced CNN variants that could work better for sequences of image patches besides consideration of paradigms linked to climate change and ecological collapse.

Smart greenhouses are also going to play key role in precision agriculture. Karanisa et al. [32] investigated on smart greenhouses in 2022 in terms of water-food- energy nexus. Their study provided inputs required by policy makers for decision making in technology driven agriculture. It includes AI, communication infrastructure and monitoring techniques to enhance water-food-energy nexus for sustainable development. Their study also shows the need for more efficient deep learning approaches in future for precision agriculture. Artificial Intelligence of Things (AIoT) isthe AI enabled technology in 21st century which advocates usage of AI and connected devices in IoT to have more useful platform for solving real world problems.

In 2023, Adli et al. [33] investigated on AIoT and its utility in precision agriculture. AIoT has an integrated approach to AI for data analytics and prediction purposes. AIoT has potential to transform conventional agriculture into modern technology-driven agriculture. It could be used to address many challenges like post- harvest management and pest management for smart agriculture. AIoT still needs improvements in terms of infrastructure, deep learning models, privacy and security.AI revolution and big data are closely related and useful for precision agriculture.

Bhat and Huang [34] investigated on technology driven agriculture in 2021 in terms of big data, agriculture and AI usage. They proposed a smart agriculture eco-system that includes IoT based data collection, data communication, usage of blockchain kind of technology, cloud IoT platform, AI for big data analytics and data visualization. However, they found the need for realizing such eco-system with optimizations in deep learning. Fuzzy based optimizations are found useful in crop monitoring research.

Towards this end, in 2021 Chouhan et al. [35] investigated on plant disease detection and classification by using fuzzy based optimization in deep learning. Their methodology integrates IoT and deep learning. It also makes use of bio-inspired algorithm known as firefly for improving network efficiency. In addition to this, their fuzzy logic inference makes it more efficient and accurate. In future they intend to incorporate other technologies like cloud, big data, sensor networks and UAV for further improving state of the art in crop monitoring. AI and nanotechnology are being used in precision agriculture.
Towards this end, Zhang et al. [36] [7] integrated deep learning and nanotechnology towards precision agriculture in 2021. They envisaged the convergence with AI and deep learning towards precision farming where farmers can use technology to respond to crop needs in real time. The technology includes consideration of soil microbes, nutrients, crop health and nano informatics. They opined that there is need for further investigation on the usage of nanotechnology in agriculture along with AI. Precision agriculture encapsulates all kinds of farming and crops.

Nasir et al. [37] focused on fruit diseases using deep learning techniques. They proposed a methodology to fine-tune pre-trained models for leveraging detection performance. They combined deep learning features and histogram-based phenomena to improve detection optimization with relevance-based approach. However, their methodology lacks support for multi-class classification of fruits and robotic forming. Data-driven AI is also used for realizing precision agriculture.
Linaza et al. [38] proposed a methodology to consider data-driven AI based methods. Their methodology includes ML and DL models, visual computing, data analytics and robotics to cover operations such as agricultural crop monitoring, management and harvesting. In future, they intend to define AI algorithms for smart farming.

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TABLE II PERFORMANCE OF DIFFERENT TECHNIQUES AND THEIR FINDINGS

References	Year	Methodology	Accuracy(%)	Findings
[39]	2023	deep learningmethod	97.9	Maize disease identificati onbased on small sample-size and complex background datasets
[40]	2023	Conventional Machine Learning and Deep Transfer Learning	97.2	Crop Disease Detection
[41]	2023	K-means clustering, Machine Learning	97.36	Grape Leaf Disease
[42]	2023	Ensemble CNN Model	99.6	Detection of Tomato Leaf Disease
[43]	2023	Deep Learning	96.73	Plant Disease Detection and Classification
[44]	2022	MachineLearning	-	Tomato Leaf Disease Detection
[45]	2022	Computer visions techniques including RGBconversion to gray, HE, K-means clustering, contour tracingand machine learning Algorithms	-	Plant leaf disease detection
[46]	2022	An efficient deep learningmodel	97.2	Potato leaf disease detection
[47]	2022	Deep Learning Techniques	97.36	Plant's Leaf Disease Detection
[48]	2022	Machine Learning	-	Detection and Prediction of Crop Diseases and Pests
[49]	2021	SVM (supportvector machine), thegray-level co-occurrence matrix (GLCM)	-	Detection of crop and prediction of pesticides
[50]	2020	Machine Learning and Deep Learning algorithm i.e. Convolutional Neural Network	-	Plant Disease Detection
[51]	2020	Machine learning	89.9	Plant leaf disease classification andDetection system
[52]	2019	Support Vector Machine (SVM), Grab Cut Segmentat ion Technique s, Global Thresholding, semisupervised Learning	93	Automated Disease Detection and Classification System for grape leaves

The study from the above survey and different authors approaches clearly states that Agriculture can be made more productive and useful with the combination of latest trends and techniques available in the learning aids. The major approaches where every author focuses are learning based approach, technology-driven approach and knowledge-based approach [53]. Among these three approaches knowledge-based approach is the oldest approach where it is hardly used in research. The other approaches are implemented in machine learning as well as deep learning.

TABLE III SUMMARY OF LEAF DISEASE DETECTION IN DIFFERENT ASPECTS

Approaches	Techniques Used	Limitations/Future Scope
Learning based	K- means clustering algorithm is used where the pixel level classification	The future scope of thisapproach is LSB based pixel can be implemented
Learning based	Machine learning technique is utilized with the classification of the diseases that effect on plantleaves	The future scope of this approach is, neural network can be implemented which has theeffect on detecting the leaf diseases and gives the higher accuracy
Technology - Driven approach	Deep learning is utilized inthe leaf disease detection where encoder network	In future scope, dependingon the seasonal crop the detection can be done using the 3-D convolutional techniques.

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Technology – Driven approach	Optimal Deep learningtechnique is used and Adaptive genetic algorithms are used	In future scope, smart detection can be used for detection and classificationtechniques using Residual networks.
Knowledge based approach	Technique used is based ontransfer learning of networks using CNN	In future Scope, the detection can be done based on computer vision and AI

III. FUTURE WORK

It is very important for the farmer to know the each and every stage of the crop growing and yield production. In this process there are certain things that a human eye or an extensive care can't be identified. To identify such unseen and dangerous disease that are spoiling the leaf to produce more crops is utmost important [54]. The survey says that if an advanced application is developed to identify these diseases, then much of the crop is saved from being damaged. In recent years, the DL techniques are highlighted and trained for image-based datasets. The application should be developed in such a way that it should detect the plant disease and providethe pesticide to prevent from such diseases to develop the crop production.

There are so many DL techniques such as CNN, RNN and GAN etc, by which we can predict the leaves disease in early-stages. The combination of two or more algorithms can be used to predict the crop leaves disease in a better way. A model can be proposed to predict the crop leaves disease with the combination of ResNet50 (which is a Deep residual networks whosemodel is a convolutional neural network (CNN) [55] [23] that is 50 layers deep. And it is an Artificial Neural Network (ANN) of a kind that stacks residual blocks on top of each other to form a network) and Xception Algorithm as shown in figure 3.

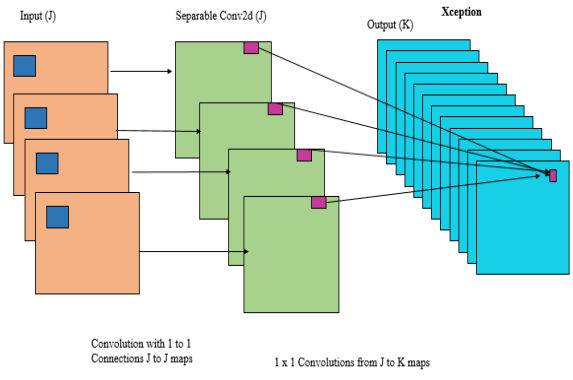

Figure 3. Architecture of Xception

The modules which will included to make a complete model are: Image Acquisition, Image Pre-processing which consists of three sub-parts such as Image segmentation, Features Extraction and classification followed by the module Network and Disease Detection and Prediction [56]. The work flow of propose model are given in below figure 4.

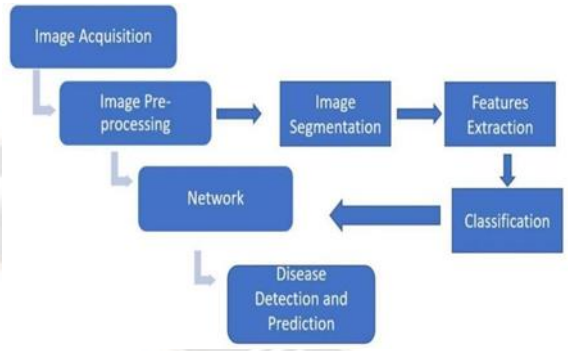

Figure 4. Work Flow of Plant Disease Detection Model

To enhance the existing model, we can use hybrid version of DL Techniques with ResNet50 and Xception technique to make the model more efficient. With the advent knowledge of this literature study one can focus on the network part of the images trained and detecting the pathogens [57] in the images at early stage. Many researchers focused on two individual sides of network and learning techniques. The amalgamation of these two things may improve the accuracy as well as early-stage detection is also possible to control the agri-loss. With the previous studies and referring to the state-of -art of the model architecture is been suggested where the amalgamation of the network and technique is reflected. In terms of network [58] [59], already many researchers presented the Deep Learning techniques, here if we use to 50 layers of Residual network with Xception techniques the more images are trained inthe network part and when feature is classified, Deep learning technique can be applied for further prediction.

The below figure 5 shows that the dataset under training section goes into the network module i.e., ResNet-50 model possess five layers where layer 1 is convolution with identity block and each convolution layer 3 CL and 3 identity block with 3 CL's. Then from those segmented image we can identify either the leaves are diseased or not.

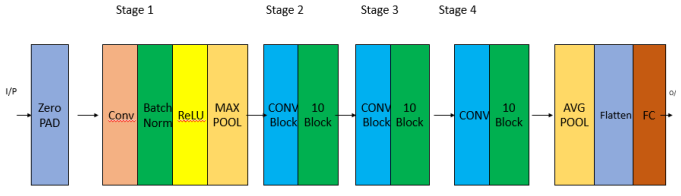

Figure 5. Architecture of ResNet50

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The very first step of propose model will be image pre-processing to make the size of image uniform which increase the speed of training [60]. After that we need to split the original dataset into training and validating parts as shown in the figure 6.

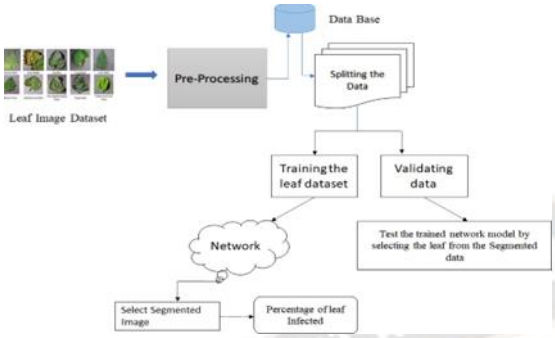

Figure 6. Architecture of Propose Model

The main purpose of suggested approach is to recognize the leaf illness or disease. We want to employ our proposed algorithm to detect the plant leaves disease for various crop leavesincluding tomato, maize, and other plant. Additionally, we want to shorten the training period toproduce meaningful results [61]. The suggested model should also be adaptable enough. The future scope of this survey can be directed towards applying security to the crop which are free from pathogens. We can extent this work by taking preventive [62] steps at the early stage after detecting the disease, this will produce more crops.

In recent years, much research is carried out in the field of image processing but the amalgamation of the real field crop with machine learning there is lot of research [63]. To fulfillall the gaps the study can implement the work using Deep Learning. The techniques involved in deep learning will enhance the minute feature of the image where every detail in the image is observed and the defect in the image is identified. As deep learning is the advanced form of machine learning which is capable to improve the performance.

IV. CONCLUSION

In this paper, we reviewed literature on precision farming with technology-driven approaches. Precision farming enables farmers to have real time response to crop needs for highest productivity and least possible expenditure. Since precision agriculture is the highest desire of all agriculture-oriented nations, efforts on this have been around in many countries including India. The research findings in this paper are multi-fold. First, AI and its associated techniquesof ML and DL are widely used in agricultural research. Second, CNN based deep learning models are found to be more effective to process image inputs. Third, IoT integration with precision farming makes it an automatic approach to capture live data and process it in real time. IoT integrated AI based system for crop monitoring is highly desired. This paper also provides important research gaps that help in moving towards the direction of precision agriculture.

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