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Apprehension of Plant Diseases by Exploiting Machine Learning & Deep Learning precepts

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***Abstract*— Plants play a pivotal role in the regulation of climate, agriculture, and economies; however, they are confronted with threats from diseases caused by bacteria, fungi, and viruses. The changing climate and weakened crop immunity have led to a surge in crop diseases, causing significant damage to crops and financial losses for farmers. Identifying and treating these diseases early is challenging due to the variety of diseases and limited farmer knowledge. Computer vision, combined with deep learning, offers a solution by leveraging leaf texture and visual features for disease identification. Plant health care involves anticipating and diagnosing life-threatening plant diseases, and early detection is key to reducing plant mortality. This study utilizes machine learning, a type of artificial intelligence, to build early prediction models for plant disease diagnosis. Machine learning addresses the difficulty of crop classification during early growth stages by employing drones with high-resolution optical imagery. These drones capture images of phonological stages, which are then used to develop characteristics based on grey level co-occurrence matrices. Various machine learning approaches, including random forest-nearest neighbors, linear regression, Naive Bayes, neural networks, and support vector machines, were employed to develop plant disease detection models. Evaluation metrics such as true positive rate, true negative rate, precision, recall, and F1-score were used to assess model performance. The results indicate that the ensemble plant disease model outperforms other proposed models. These predictive models aim to identify diseases in early stages, enabling timely preventive actions and predictive maintenance for plant health.**

***Index Terms*— Resource Optimization, Risk Mitigation, resilience, Convolutional Neural Network, Recurrent Neural Network and Empowering Farmers.**

I. INTRODUCTION

In the modern era, advanced technology empowers us to generate enough food to satisfy the demands of the expanding global population. India, occupying the largest portion of the country, maintains ties to agriculture for about 70% of its population [ ]. Looking ahead, research suggests that by 2050, we could enhance crop production by a minimum of 50%. This underscores the significance of in placing greater emphasis on both indoor and outdoor farming practices. Plant diseases and pests refer to a category of natural challenges that disrupt the regular development of plants, sometimes leading to the death of plants throughout their entire growth cycle – from the early stage of seed development to becoming seedlings and further growth. When dealing with tasks related to machine vision, identifying plant diseases and pests is often based on human knowledge and experience, rather than being solely defined through mathematical concepts.

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The majority of farmers are financially disadvantaged and find it challenging to make significant changes. However, they have a desire to improve their situation, and they encounter various problems related to pests and plant diseases. Growing fruits and vegetables is a common practice among them. To protect their crops, they often use potent chemicals. Unfortunately, these chemicals can have harmful effects on the environment – affecting the quality of soil, air, and water – and they can also impact human health negatively. Farmers in rural areas might find it difficult to detect diseases in their crops. Going to an agricultural office to figure out what's wrong is not easy for them. Our main goal is to use pictures and computer learning to figure out what disease a plant has by looking at its shape and features. Pests and diseases can destroy crops and parts of plants, which means less food is grown. This can make it hard for people to have enough to eat. Many poorer countries don't know how to deal with these problems well. Harmful germs, not controlling diseases, and big changes in weather are some of the main reasons why food isn't being produced as much.

II. Motivation

Plant disease detection projects forefront agricultural advancement through technology, ensuring early disease identification for improved crop yield, quality, and food security. Successes include reduced losses, sustainable practices, resource optimization, and community empowerment. Data-driven insights, collaboration, and innovative warning systems bolster disease management and harvest protection. Aligned with sustainability, these initiatives enhance global food production, resilience, and environmental preservation, while leveraging technology for resilient farming practices and risk mitigation. Our Project will reduce a large work of monitoring in big farms of crops at very early stage it detects the symptoms of diseases so it alarm regarding this before much damage has going to happen.

III. Scope

Agricultural lands are more than just being a feeding source across the world. Our Indian economy is highly dependent on agricultural productivity, therefore field of plant disease detection technique is beneficial. The existing method of plant disease detection is naked eye observation by expert through which they can identify and detect plant disease. Our project is very much beneficial in agricultural area which is base of any development. As our Indian farmer does not equip with much technology for growth of plant and agriculture and due to several factors, such as -light, water, temperature, nutrients, insects etc. they faced much problem in growing crops, plants etc. Our project detect disease in plants and help them to act based on that.

IV. Use (Background)

Plant disease detection projects integrate computer vision, machine learning, and deep learning to identify plant diseases accurately. Utilizing tools like preprocess images, segment plants, and extract features for classification. Algorithms such as CNNs, SVMs, RNN and ensemble methods distinguish between healthy and diseased plants. IoT devices collect real-time data for risk assessment, while mobile apps enable farmers to capture images and receive instant diagnoses. GIS aids spatial insights, and cloud computing facilitates scalable model training and hosting. This amalgamation of techniques and tools enhances agricultural practices by providing timely disease detection and insights to ensure healthier crops.

V. Problem Statement

Agriculture is one of the important sector of Indian economy Employment to almost 50% of the countries. Farmer’s economic growth depend on the quality of product that they produce, which relies on plant growth and the yield they get. Therefore, in field of agriculture, detection of disease in plants plays a very vital role. So in this project we develop an efficient plant disease detection system using machine learning techniques that can detect diseases at an early stage when symptoms are not visible to naked eyes. So our project help in empowering farmers with a powerful tool for early disease detection and management, ultimately contributing to increased crop yields, reduced agricultural losses, and improved food security.

VI. Methodology

Plants are basic building blocks for human survival and existence .Plant and agriculture play a crucial role in our lives, and influencing various aspects. Importance of plants for humankind is multifaceted, encompassing vital roles in nutrition, medicine, industry, environmental balance, and cultural practices. And also, disease detection in

plants plays a very crucial role in our lives. Without proper identification of the disease and the disease-causing agent, disease control measures can be a waste of time and money and can lead to further plant losses .And our project aim is to diagnose the disease in plant before much loss happen to it or our farmers. In our project we mainly work on CNN (convolutional neural network) to detect or predict disease in plants.

CNN(Convolutional Neural Network)

A convolutional neural network is a network architecture for deep learning which learns directly from data. It is a feed-forward network that is generally used to analyse visual images by processing the data. CNN use to classify and detect object in an image. CNN has multiple hidden layers which help in extracting information or pattern from the given image.In our project we basically and mainly perform our disease prediction on potato leaf by taking dataset and do training and testing. There are two common disease in potato which we depict in our project i.e. -i) Early blight ii) Late blight

1) Early blight- caused by fungus and favoured by warm temperatures and high humidity.
2) Late blight-caused by phytophthora infestans and favoured by cool and moist weather.

The given system is classified into these modules-

1) Data collection
2) Cleansing the data
3) Loaded data into tensorflow dataset.
4) Visualization
5) Train test split
6) Data pre-processing
7) Model building
8) Machine learning operations.
9) Testing dataset prediction
10) Predicted model visualization.

1) Data Collection

In our project we use dataset name “Plant Village” which consist of data of potato early blight, late blight and healthy leaves. Then we download the data set into tensor flow.

2) Cleansing the data

It includes finding missing, imprecise, or unnecessary portion of data and then replacing, removing or altering the unclean data.

3) Loaded data into tensor flow dataset

So we download the images through tensor flow by using tf.data.datset command. The use of tensorflow dataset is that it read the images into batches and enable easy to use, high performance input pipelines. In this process we randomly shuffle the image before loading them.

4) Visualization

In this almost all image size are- 256x256 taken and we make 32 batch size of images which is standard. Then for visualization of the image we use matplotlib library and give plt.imshow() command and then finally do printing which give the visualization of image and since we randomly shuffle the image before loading so everytime we get different visualization result and In this we also display the label along with image showing whether it is early blight or late blight.

5) Train test split

So we spilt our process into three parts- i)80% ->training ii)10% ->validatio iii)10% -> test. We load the image here and optimize for training performance. So here validation data set do the validation and test dataset measures the accuracy of the model.

6) Data preprocessing

A machine learning algorithm’s ability to generalize is frequently impacted by data preparation stage. Data quality and representativity is the first and most crucial need to guarantee the efficient building of the model. For preprocessing we created layers in our model.

7) Model Building

For building model we use convolutional neural network (CNN) which consist of convolutional , ReLU and Pooling layers. In this we resize and rescale our image sample, after that we perform data augmentation. Then we use filter on various layer, using activation function etc. then we get the summary which include total parameters

8) Machine learning operations.

So in ML operation we do validation, testing, optimization and measuring the accuracy of our result using libraries and functions.

9) Testing dataset prediction

In this we testing our dataset by taking particular number of epoch and by tracking accuracy of each epoch. After using ML operations we get history parameter of each epoch which contain loss and accuracy probability. And then after history parameters of each epoch we can plot them in a nice matplotlib chart.

10) Predicted model visualization

And then at the end we get predicted model visualization of the selected length of the image which showing visuals of the leaf with actual, predicted and confidence label.

TABLE I. LITERATURE SURVEY

S.no	Paper title	Authors	Algorithm used	Methodology	Advantage	Results	Journal Name	LINK	Year of Publication
1	Plant Disease Identification using AI: ML approach	Jubin Dipak, kumar Kothari	ML Algorithms: Supervised, unsupervised, Semi supervised, reinforcement learning	The paper discusses various machine learning methods for plant disease detection but lacks critical details on dataset, preprocessing, model architecture, and evaluation methods, hindering research reproducibility.	Automation, Accuracy, Speed, Scalability, Accessibility	It explores machine learning's applications and benefits in agriculture.	International Journal of Innovative Research in Science, Engineering and Technology	https://papers.ssrn.com/sol3/papers.cfm?abstract_id=8728753	11 November 2018
2	Plant disease detection using machine learning	Mrs. Shimla Ramesh, Niveditha M, Mr. Ramachandra Hebbar, Mr. P V Vinod	Random Forest	disease detection involves resizing images for consistency and extracting features like Hu Moments, Haralick Texture, and Color Histogram to differentiate healthy and diseased leaves, aiming to improve accuracy.	Ensemble Learning, Feature Extraction, Interpretable	The Random Forest achieved a 70.14% accuracy in leaf classification.	2018 International Conference on Design Innovations for 3Cs Compute Communicate Control	https://ieeexplore.ieee.org/abstract/document/8437085/	Apr-18
3	Plant Disease Detection Using Image Processing & ML	Pranesh Kulkarni1 , Atharva Karwande1 , Tejas Kolhe1 , Soham Kamble1 , Akshay Joshi1 , Medha Wyawahare1	Random Forest Classifier	The methodology employs Plant Village dataset with 87,000 plant images. Preprocessing involves grayscale conversion, filtering, and feature extraction, followed by Random Forest classification, feature selection, and evaluation using k-fold cross-validation.	High accuracy, Ensemble Learning, Feature Selection	Proposed method achieves 93% average accuracy, effectively classifying plant diseases.	Department of Electronics and Telecommunication, Vishwakarma Institute of Technology, Pune, India.	https://arxiv.org/ftp/arxiv/papers/2106/2106.10698.pdf	Jun-21
4	Plant disease detection using deep convolution-al neural network (DCNN)	J. Arun Pandian, V. Dhilip Kumar, Oana Geman, Mihaela Hnatiuc, Muhammad Arif, K. Kanchanadevi	Deep Convolutional neural network (DCNN)	collection, augmentation, 14-DCNN model design, hyperparameter tuning, training, real-time disease prediction, and TensorFlow Lite conversion for plant leaf disease detection.	High accuracy at image recognition ,no human supervision required	Computationally Intensive, Model Complexity, Limited Explanation		https://www.mdpi.com/2076-3417/12/14/6982	Jul-22
5	Plant leaf disease detection using machine learning	Sudhanshu Kaushik, Khushi Srivastava	Convolutional neural network (CNN)	Utilize Plant Village dataset, employ data augmentation, enable user photo uploads, preprocess images, label healthy/diseased, train CNN classifiers, and evaluate for disease recognition.	High computational power, high accuracy rate	In this kernel used in each image & we get better and more detailed of image	Journal of Pharmaceutical Negative Results	https://pnrjournal.com/index.php/home/article/view/9442	2022
6	ResTS: Residual Deep interpretable architecture for plant disease detection	Dhruvil Shah, Vishvesh Trivedi, Vinay Sheth, Aakash Shah, Uttam Chauhan.	ResTS (Residual TeacherStudent) based on a neural network architecture	The methodology utilizes ResTS architecture for plant disease classification and visualization with PlantVillage data. It employs Xception, residual connections, and batch normalization for performance improvement.	Res1S: Enhanced training, visualization, efficiency; robust, adaptable, precise plant disease	Res1S with residual connections and batch normalization excels in plant disease diagnosis, providing	Dep of CS, Vishwakarma Government Engg College, Chandkheda, Ahmedabad 382424, Gujarat, India	https://www.sciencedirect.com/science/article/pii/S2214317321000482	04-Jun-21
7	PlantDoc: A Dataset for Visual Plant Disease Detection	Davinder Sing, Naman Jain, Pranjali Jain, Pratik Kayal, Sudhakar Kumawat, Nipun Batra	Utilized VGG16, InceptionV3, InceptionResNetV2, MobileNet for image classification, Faster R-CNN	The paper presents "PlantDoc" dataset, evaluates deep learning models for plant disease detection using 2,598 images, highlighting its importance in real-world scenarios.	PlantDoc enhances real-world plant disease detection with diverse data and accessibility.	"PlantDoc dataset enhances plant disease detection, improving accuracy in real-world conditions. Object detection models perform	Indian Institute of Technology Gandhinagar, Gujarat, India 382 355	https://arxiv.org/pdf/1911.10317.pdf	23-Nov-19
8	A Review on Machine Learning Classification Techniques for Plant Disease Detection	Mrs. Shruthi U, Dr. Nagaveni V, Dr. Raghavendra B K	The paper reviews machine learning algorithms (SVM, ANN, KNN, Fuzzy, CNN) for plant disease detection, without proposing a new	The paper reviews plant disease detection methods, compares SVM, ANN, KNN, Fuzzy Classifier, and CNN, concluding that CNN holds promise. No original experiments were conducted.	The advantage of these algorithms is their potential to accurately identify and classify plant diseases, aiding in early detection and treatment.	The paper compares machine learning methods for plant disease detection, with CNN showing higher accuracy across various crops.	2019 5th International Conference on Advanced Computing & Communication Systems (ICACCS)	https://www.researchgate.net/publication/345425902_A_Review_on_Machine_Learning_Classification_Techniques_for_Plant_Dise	Mar-19
9	Rice Leaf Disease Detection Using Machine Learning Techniques	Kawcher Ahmed, Tasmia Rahman Shahid, Syed Md. Irfanul Alam and Sifat Momen	ML (Logistic Regression, KNN, Decision Tree, Naive Bayes) to detect rice leaf diseases, achieving 97% accuracy with Decision Tree.	The methodology includes collecting, preprocessing rice leaf images, extracting features, splitting data, applying ML algorithms, evaluating, and concluding Decision Tree's superior performance, with future work recommendations.	Paper compares KNN, Decision Trees, Logistic Regression, and Naive Bayes.	Paper on rice leaf disease detection using Decision Tree algorithm.	2019 International Conference on Sustainable Technologies for Industry 4.0 (STI), 24-25 December, Dhaka	https://ieeexplore.ieee.org/abstract/document/9068036	Dec-19
10	Plant Disease Detection Mobile Application Development using Deep	Ng Hui Fuang, Lin Chih-Yang, Chuah Joon Huang, Tan Hung Khoon & Leung Kar Hang	Paper employs Faster R-CNN with Inception-v2 backbone for precise	Utilizes Faster R-CNN with Inception-v2 backbone for precise object detection, combining a Region Proposal Network (RPN) and a detection network for accuracy.	Faster R-CNN with Inception-v2 for efficient, accurate object detection in	Paper: Mobile app achieves 97.9% accuracy in grape leaf disease detection.	International conference on computer and information sciences(ICCCNS)		2021

11	**Image based plant disease detection with deep learning**	Ashwin Dhakal , Prof. Dr. Subarna Shakya.	Focuses on deep learning, especially CNNs, for plant disease detection.	Data extraction efficiently,Image pre-processing and normalization,Image augmentation,design of ANN,training neural network,loss function.	High accuracy in disease detection with image augmentation to prevent overfitting.	Impressive 98.59% accuracy in plant disease detection with deep learning.	International general of computer trends and trehnology(IJCTT)		01-Jul-1
12	**Crop disease detection using machine learning-Indain agriculture**	Adhao Asmita Sarangdhar , V. R. Pawar, Delwicke, M. S. Kim ,etc.	Canny edge detection employed to identify diseases in crop plants..	Methodology- It involves collecting healthy and diseased crop images for different types of crops ,M.L. technique used to train model.Disease detction also used in this.	Early crop disease detection enables timely action, reducing manual	The paper outlines the method for crop disease detection but lacks results.	International research journal of Engineering and technology(IRJET)		Sep-1
13	**Crop leaf disease detection and classification using ML and DP algorithms by visual**	Pallepati Vasavi , Arumugam Punitha, T.Venkat Narayana Rao	Various algorithms applied, including SVM, K-NN, Random Forest, NB,	The methodology involves a multi-step process, including image acquisition, image preprocessing, image segmentation, feature extraction, and classification.	High accuracy in crop disease prediction, enhancing agricultural yield.	Accuracy varies, reaching up to 99.5% depending on dataset and method.	International Journal of Electrical and Computer Engineering(IJECE)	https://core.ac.uk/reader/482068162	Aug-2
14	**Plant disease identification using Deep Learning: A review**	sapna nigam and rajni jain	Focus on CNNs, with mentions of SVM and Back Propagation.	It uses a combination of image processing techniques and deep learning models for disease identification , followed by image acquisition, image pre-processing, feature extraction, and classification.	High accuracy, automatic feature extraction, faster processing	Deep learning (CNNs) achieve 95-99.84% accuracy; SVM, BPNN reach 79.5-97.2%	Indian journal of agricultural science(IGAS)		Jul-1
15	**Plant Disease Detection using Deep Learning**	Murk Chohan, Adil Khan, Fiza Chohan, Saif Hassan Katpar, Muhammad Saleem Mahar	Paper uses Convolutional Neural Network (CNN) for plant disease detection.	The paper suggests a deep learning-based method for plant disease detection, achieving 98% accuracy. It discusses data collection, CNN training, real-world testing, and potential drone integration.	CNNs for plant disease detection: automatic, accurate, adaptable, real-time potential.	The model achieved 98.3% accuracy in detecting plant diseases effectively.	International Journal of Recent Technology and Engineering (IJRTE)	https://www.	01-May-2

The papers discuss machine learning and deep learning approaches for plant disease detection. They highlight the significance of ai in agriculture for disease identification and crop management. Methods like random forest, cnns, and dcnns are used, with emphasis on dataset diversity, preprocessing techniques, and high accuracy rates ranging from 70% to 97.9%. Some papers introduce novel algorithms like rests for disease classification and visualization. Overall, these studies underscore the potential of ml in early disease detection, aiding in timely treatment and improved crop yield.

VII. Figures And Tables

A. Result

As a result we get visual of leaf with actual, predicted and confidence label and history parameter which shows loss and accuracy probability .And on an average we found that with the help of CNN algorithm our accuracy reach approximately 98% in detection of disease in plant because of the training we given to our dataset which is as shown below.

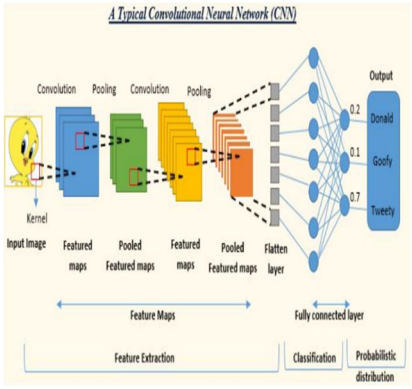

Figure 1. Convolutional Neural Network

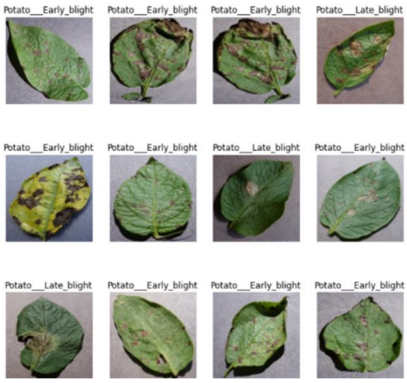

Figure 2. Image Visualization samples

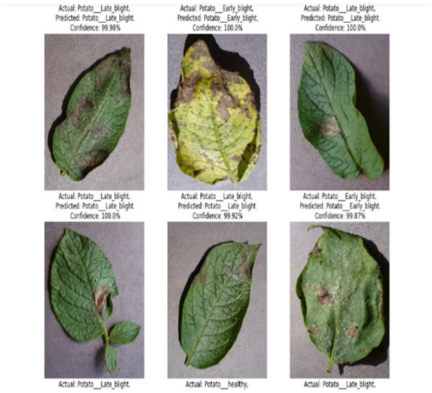

Figure 3. Predicted model visualization

conv2d (Conv2D)	(32, 254, 254, 32)	896
max_pooling2d (MaxPooling2D)	(32, 127, 127, 32)	0
conv2d_1 (Conv2D)	(32, 125, 125, 64)	18496
max_pooling2d_1 (MaxPooling2	(32, 62, 62, 64)	0
conv2d_2 (Conv2D)	(32, 60, 60, 64)	36928
max_pooling2d_2 (MaxPooling2	(32, 30, 30, 64)	0
conv2d_3 (Conv2D)	(32, 28, 28, 64)	36928
max_pooling2d_3 (MaxPooling2	(32, 14, 14, 64)	0
conv2d_4 (Conv2D)	(32, 12, 12, 64)	36928
max_pooling2d_4 (MaxPooling2	(32, 6, 6, 64)	0
conv2d_5 (Conv2D)	(32, 4, 4, 64)	36928
max_pooling2d_5 (MaxPooling2	(32, 2, 2, 64)	0
flatten (Flatten)	(32, 256)	0
dense (Dense)	(32, 64)	16448
dense_1 (Dense)	(32, 3)	195

Total params: 183,747
Trainable params: 183,747
Non-trainable params: 0

Figure 4. Result

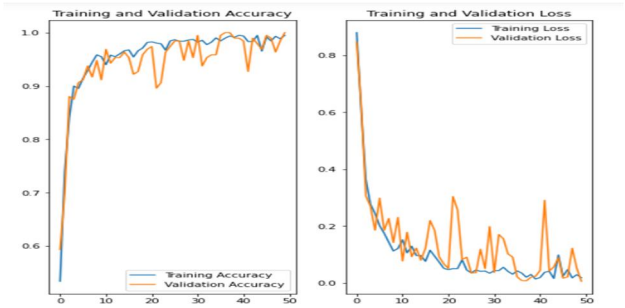

Figure 5.Testing dataset Prediction

B. Abbreviations and Acronyms

ML: Machine Learning

Machine learning is a subset of artificial intelligence (AI) that focuses on the development of algorithms and models that allow computers to learn and improve from experience without being explicitly programmed. Used to analyze large amount of data and pattern in plant disease detection.

CNN: Convolutional Neural Network

A convolutional neural network is a network architecture for deep learning which learns directly from data. And it analyze visual image by processing the data.

RNN: Recurrent Neural Network

It is a type of neural network architecture designed to handle sequential data by maintaining an internal state (memory) to process sequences of inputs. It Give satisfactory result but less effective than CNN.

KNN: K- Nearest Neighbour

Instance-based learning algorithm used for classification and regression tasks. But it has limitation when applied to high dimensional data such as images we used this for comparison of result with CNN algorithm.

ReLu: Rectified Linear Unit

It is one of the layer in Convolutional Neural Network used to introduce Non-linearity in networks.

E. Equations

A Convolutional Neural Network (CNN) is a deep learning model commonly used for image recognition and classification tasks.
Mathematical representation of convolutional neural network (CNN) algorithms:

Convolutional layer :

$$Z_{i,j}(l)=\sigma(\sum_{k=1}^{n(l-1)}\sum_{m=1}^{f(l)}\sum_{n=1}^{f(l)}W_{m,n,k}(l)\cdot X_{i+m-1,j+n-1,k}(l-1)+b_{i,j}(l)) \quad \text{--- (1)}$$

Activation Layer:

$$A=ReLU(Z) \quad \text{--- (2)}$$

Pooling Layer (e.g., Max Pooling):

$$Z_{i,j}(l)=pooling\_function(X_{i,j}(l)) \quad \text{---(3)}$$

Fully Connected Layer:

$$Z_j(l)=\sigma(\sum_{i=1}^{n(l-1)}W_{ij}(l)\cdot A_i(l-1)+b_j(l)) \quad \text{---(4)}$$

F. Other Recommendations

Apart from plant disease detection image classification and regression algorithm i.e. RCN,CNN etc. used in various fields like- medical imagining such as X-rays, MRIs, and CT scans ,Used in the development of self-driving cars, used to analyze satellite images for various applications, including monitoring land use, urban planning, disaster management, and environmental monitoring. Also used for facial recognition in security systems, authentication mechanisms etc.

VIII. CONCLUSIONS

Promising accuracy and prediction skills are shown by convolutional Neural Network (CNN).This model perform very well in identifying complex patterns. By means of extensive training on dataset model got the ability to identify and distinguish which one is healthy plant(leaf) or which one is the diseased one. CNN with the help of it's different hidden layer it can recognize the pattern very effectively and efficiently. And give accuracy % approximate. We also read RCNN algorithm and we see that it first identifies potential region of interest and then apply CNN to each proposed region for object classification. And due to this two stage process it become computationally expensive and slow in comparison to CNN and less accurate.
Talking about KNN algorithm it has limitation when applied to high dimensional data such as images, as it can suffer from the inappropriateness in dimensionality and it is also less accurate, precise and efficient as comparison to CNN Algorithm.

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