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TESTING OF A MATHEMATICAL MODEL FOR THE CLASSIFICATION OF DISEASES IN AGRICULTURAL PLANTS USING CONVOLUTIONAL NEURAL NETWORKS

VIVEK SRIVASTAVA, SONAL SAXENA

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Abstract

Plants are the most important contributor to the production of food for societies through agriculture. Plant diseases can have a negative impact not only on production costs but also on human health. In order to keep these disorders under control, constant monitoring of their progression is required. The traditional techniques of monitoring these disorders require a significant amount of time and effort. It is an extremely lengthy document that has several typos in it. We are currently living through a transition into a new era characterised by emerging tendencies and technologies such as machine learning, deep learning, and artificial intelligence. These developments have the potential to assist in mitigating the negative effects of disease and overcoming the limitations imposed by human monitoring. In the course of this body of work involving study, we investigated various CNN classification models using 22,912 tomato leaf pictures. These models included Resnet, Resnet18, DenseNet201, VGG16, VGG19, InceptionV3, Imagenet, and MobileNet. Within the scope of our investigation, we made use of Google Collaborative, trained the model, and then reported on the degree to which each model accurately classified 10 distinct categories of photographs (healthy and different types of unhealthy). It has been demonstrated that DenseNet201 has an accuracy of 98.11 percent. The findings have been compared with the findings of studies on machine learning carried out by other researchers, and it has been discovered that the deep learning model is more accurate than other machine learning models in identifying tomato leaf illnesses.

Keywords: Deep Learning, Convolutional Neural Network, Transfer Learning, Agriculture, Classification

1. INTRODUCTION

The field of horticulture now daily was assuming the critical part in worldwide economy. As the huge expansion in the populaces requires more spaces for houses, street extension, rail lines line advancement in the metropolitan regions. The effect of urbanization rapidly diminishes the developed grounds prompts increment the nervousness of agribusiness framework. Tomato takes up a high up place on the planet horticulture economy. As a matter of fact, as indicated by the report given by food and farming association of United States (FAOSTAT) [1], the development of per yield amount of tomato on the planet was 176 million tons in 2016 and 182 million tons in 2019. The best ten nations in the creation of tomatoes are China, India, Turkey, USA, Egypt, Italy, Iran, Spain, Mexico and Brazil. The various types of illnesses constantly passed judgment on factors in the cultivating of tomato. At the point when the tomato crops are exceptionally tainted by these infections then, at that point, the creation of tomato diminishes and reason amazing misfortunes in the agribusiness economy. Most normal illnesses are brought about by different organisms, microbes and infections. To safeguard the tomato at the beginning phase is a significant assignment for two reasons: 1. to work on the nature of tomato crops. 2. To build the development of tomato. We require some shrewd framework in such way that it distinguishes the sicknesses at the beginning phase and great recognizable proof of infection helps the development of tomato crops as well as proficiency that prompts increment the worldwide agribusiness economy. For good ID and early identification of infection, the expert must require scholastic preparation, inescapable information on different disciplines alongside the enormous number and variety causes by the sickness. Also, agriculturists should screen plants unendingly seeming a tedious task.

Lately, Deep Learning [5] has given an extraordinary outcome in intellectual and industry world, agreeing to the two taking after reasons first and foremost; far reaching amounts of data are made every day. Subsequently, this data can be used in organize to prepare a profound model. Moreover, the force of figuring given by Graphics Processing Unit (GPU) and High-Performance Computing (HPC) makes possible the planning of profound models and utilizing the parallelism of registering. One of the profound learning configuration names CNN end up being the most magnificent in picture arrangement and made unprecedented interaction. DL was feasibly used in varying tasks, for example, fight area,

Department of Computer Science & Engineering, Institute of Engineering & Technology, SAGE University Indore, India
*Corresponding author email- reachtovivek@gmail.com

content examination, semantic division and scene examination. The CNN show works with two stages, regardless one is to catch the image of the trim or the regular item agreeing to our fascinated and the second one is to support the caught picture into the created exhibit for cutting edge examination and to prompt the outcome. Various computations and systems are associated with the realized CNN plans like AlexNet, VGGNet, GoogleNet, ResNet and SqeezeNet to acknowledge promising outcomes [2-3]. The realized methodology is move learning, information increase, hyper boundary tuning, data preprocessing techniques, object recognition and picture division. The known data preprocessing techniques are resizing, foundation removal, and frontal area pixel extraction, production of jumping boxes, picture space change, histogram and PCA [4]. The ramifications of this paper is to gather the greatest work in the field of tomato infection ID, tomato arrangement; different AI and profound learning design have been utilized. [4] It additionally assists with observing the exploration holes for the future analysts to foster the more experienced and characterized framework to sort and resolve the examination hole in the field of farming.

Thusly, enormous endeavors have been surrendered to accompanying a strategy that robotizes the grouping of disease using leave pictures. The place of these methodologies is to early recognize the contamination, fixating on the fitting treatment at the appropriate time [5-8]. Additionally, these methodologies depend on Machine Learning and Computer Vision to develop a classifier of disease using the image of fair the leaf. In regard to building such classifier, features are removed from pictures to energize crafted by classifier. The experts make these features, known as handmade elements to remove critical information from pictures. Accordingly, the learning structure isn't totally modernized since of the dependence on the hand-made highlights [9]. After the extraction of component stage, the classifier is arranged using named pictures. Sadly, gathering this marked data is uncommonly exorbitant, since the naming is done actually by an expert, who can take a gander at the image and to name it with the appropriate sickness. Profound Learning could be an advanced inclination in Machine Learning and it beats condition of the craftsmanship in various examine fields, like Computer Vision, Drug Design and bioinformatics [5]. The upside of Deep Learning is the ability to mishandle explicitly crude data without using the carefully assembled highlights [5-6].The remaining portion of this paper consists of following sections: section-2 will give details of diseases of tomato, section-3 will give the review of the background work, section-4 presents the research methodology, section-5 presents experiment carried out, section-6 will discuss the result based on the experiment performed and section-7 will conclude the paper and provides the future direction.

2. CATEGORIES & SYMPTOMS OF TOMATO CROP

Classification of Diseases of Tomato Crop

The tomato crop jumble comparably marked inside side the accompanying classes. The to be expected spot infections emerge inside side the plant crop due to parasitic, microorganism, infection, buildup and vermin. The classes are then sub arranged into exceptional classes. The contagious microorganisms of tomato problem fuse early splendid, septoria leaf, target spot and leaf shape sicknesses. [10] The microbes microorganisms fuse microscopic organism's spot. The Virus Pathogens consolidate late brilliant. The form microbes fuse tomato mosaic infection and tomato yellow leaf infection and the moderate microorganisms consolidate saw infections. In this notice we've sorted remarkable classes and indications of the tomato plant. We saw those microorganisms global and they're currently done influencing the tomato crop anyway various types of the vegetation also. The early recognition in such species jars benefits to the rancher and restorative greens can be to be had to the individuals.

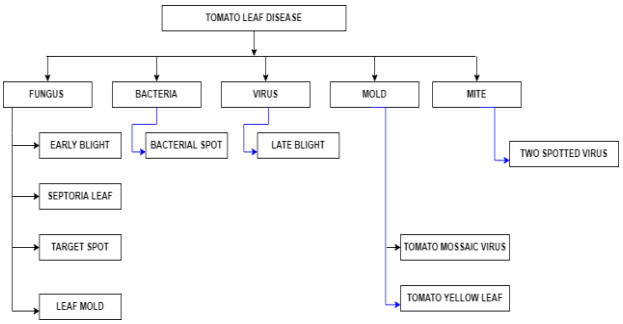

Figure 1 Classification of Tomato Crop Disease

Symptoms of Tomato Crop

Early Bight

It is caused by fungus. Early blight signs and symptoms begin as oval formed lesions with a yellow chlorotic place throughout the lesion; concentric leaf lesions can be visible on inflamed leaves; leaf tissue among veins is destroyed; intense infections can purpose leaves to absolutely collapse; [10]because the disorder progresses leaves turn out to be critically blighted main to decreased yield; tomato stems might also additionally turn out to be inflamed with the fungus main to Alternaria stem canker; Disease can unfold unexpectedly after plant life have set fruit; motion of air-borne spores and get in touch with infested soil are reasons for the unfold of the disorder.

Leaf Mold

It is caused by fungus. The disease occurs in tomato plant due to humidity and it is very common in the green house tomato crop. The older leaves show off faded greenish to yellow spots on higher surface. Whereas the decrease part of the spot shows off green to brown smooth fungal expansion [10]. As the ailment development the spots might also additionally blend and seem brown. The inflamed leaves grow to be with and die however live connected to the plant. The fungus additionally infects plants and fruits. The affected plants grow to be black and drop off. The affected fruit to begin with indicates clean black abnormal vicinity at the stem give up however later it will become sunken, leathery and dry.

Septoria Leaf Spot

It is caused by fungus. Symptoms might also additionally arise at any level of tomato improvement and start as small [10], water-soaked spots or round grayish-white spots on the bottom of older leaves; spots have a grayish middle and a darkish margin and they will join together; fungal

fruiting our bodies are seen as tiny black specks within side the middle of spot; spots can also seem on stems, fruit calyxes, and flowers.

Target Spot

it is caused due to fungus. The fungus infects all elements of plant. Infected leaves suggest small, pinpoint, water-soaked spots initially. As the disorder development the spots extend to emerge as necrotic lesions with conspicuous concentric circles, darkish margins and mild brown centers [10]. Whereas the culmination showcases brown, barely sunken flecks within side the starting however later the lesions emerge as big pitted appearance.

Bacterial Spot

It is mainly caused due to bacteria. Bacterial spot lesions begins off evolved out as small water-soaked spots; lesions grow to be extra severa and coalesce to shape necrotic regions at the leaves giving them a blighted look; of leaves drop from the plant extreme defoliation can arise leaving the fruit vulnerable to sunscald; mature spots have a greasy look and can seem obvious while held as much as light [10]; facilities of lesions dry up and fall out of the leaf; blighted leaves regularly continue to be connected to the plant and supply it a blighted look; fruit infections begin as a barely raised blister; lesions might also additionally have a faint halo which finally disappears; lesions on fruit might also additionally have a raised margin and sunken middle which offers the fruit a scabby look.

Late Blight

It is mainly caused by Oomycete. Late blight affects all aerial components of the tomato plant; initial symptoms of the malady seem as water- soaked inexperienced to black areas on leaves that speedily change to brown lesions [10]. down like white plant life growth might appear on infected areas and leaf undersides throughout wet weather; because the disease progresses, foliage becomes shriveled and brown and also the entire plant may die; fruit lesions begin as on an irregular basis formed water-soaked regions and alter to greasy spots; entire fruit may become infected and a white fuzzy growth may appear during wet weather.

Tomato Mosaic Virus

It is mainly caused by virus. Symptoms can arise at any increase degree and any a part of the plant may be affected; inflamed leaves commonly showcase a darkish inexperienced mottling or mosaic; a few lines of the virus can motive yellow mottling at the leaves; younger leaves can be stunted or distorted; seriously inflamed leaves may also have raised inexperienced areas; fruit yields are decreased in inflamed plants; inexperienced fruit may also have yellow blotches or necrotic spots; darkish necrotic streaks may also seem at the stems, petioles leaves and fruit.

Tomato Yellow Leaf Curl disease

It is mainly caused by virus. The inflamed leaves come to be decreased in size, curl upward, seem crumpled and display yellowing of veins and leaf margins [10]. The internodes come to be shorter and entire plant seems stunted and bushy. The entire plant stands erect with best upright growth. The flora might not increase and drop off.

Spider Mites

It is mainly caused by arachnid. Leaves stippled with yellow; leaves can also additionally seem bronzed; webbing protecting leaves [10]; mites can be seen as tiny shifting dots at the webs or underside of leaves, first-class considered the use of a hand lens; normally now no longer noticed till there are seen signs and symptoms at the plant; leaves flip yellow and can drop from plant.

3. RELATED WORK

Hongkun Tian et al: Computer inventive and judicious is a region that incorporates making a machine "see". This age utilizes an advanced digi cam and PC rather than the natural eye to recognize, tune and measure targets for picture handling. With the improvement of PC inventive and farsighted, such age has been broadly utilized inside side the area of rural computerization and fills a critical role in its improvement. This assessment methodically sums up and investigates the innovation and requesting circumstances in the course of the most recent 3 years and investigates predetermination prospects to shape the best-in-class reference for specialists. Through the examinations, its miles found that the overall age can help the improvement of rural computerization for little region cultivating to secure the endowments of minimal expense, inordinate execution and unreasonable accuracy. In any case, there are by and by principle requesting circumstances. In the first place, the age will continue to intensify into new programming districts inside side the fate, and there could be more noteworthy mechanical issues that need to be survived. It is fundamental to develop enormous scope data sets. Second, with the quick improvement of farming mechanization, the call for specialists will keep to develop. At long last, the strong in general execution of related innovation in various confounded conditions might even face requesting circumstances. Through assessment and conversation, we acknowledge as obvious with that inside side the fate, PC inventive and perceptive age could be mixed with sharp age which incorporates profound acquiring information on age, be completed to every component of farming assembling control basically founded absolutely for enormous scope datasets, be more noteworthy widely used to cure the advanced rural issues, and higher upgrade the financial, in vogue and durable in general execution of horticultural computerization structures, therefore selling the improvement of agrarian robotization framework and constructions in a more prominent astute course.

Kamilaris et al: Deep learning comprises a new, present-day strategy for picture handling and records investigation, with promising impacts and tremendous potential. As profound learning has been accurately carried out in assorted areas, it has recently entered moreover the area of agribusiness. In this paper, the scientist does an overview of 40 investigations endeavors that enlist profound learning methods, executed to assorted rural and suppers fabricating difficulties. he notices the interesting horticultural difficulties beneath notice, the exact designs and systems utilized, the sources, nature and pre-handling of records utilized, and the overall generally execution performed reliable with the

measurements utilized at each picture underneath notice. In addition, he additionally notices correlations of profound learning with various current well-known methods, in appreciate to varieties in classification or relapse in general execution. His discoveries recommend that profound figuring out how to know offers over the top precision, beating current normally utilized picture handling strategies.

Nagaraju M et al: Automatic personality of sicknesses through hyper otherworldly pictures is a totally significant and essential errand for manageable cultivating and won the eye of analysts for the length of the past couple of years. The innovation proposed, and techniques followed up to now are insulted of their extension and totally dependent upon profound learning styles. The general exhibition of Convolutional brain networks is rising in light of the fact that the most extremely successful gadget to analyze and are expecting the contaminations from the yield pictures. In this article, the specialist has looked into some of the predominant brain organization's methodologies which may be utilized to handle picture information with noticeable quality on distinguishing crop illnesses. He First, assessed the realities securing sources, profound learning styles/structures, and interesting picture handling systems used to deal with the imaging information gave. Second, the investigate featured the results got from the evaluation of various current profound learning designs and eventually refered to the future extension for hyperspectral realities examination. The overview is to allow future examinations to explore huge capacities of profound figuring out how to know simultaneously as identifying plant infections with the guide of utilizing improving machine by and large execution and precision.

Iftikhar Ahmad et al: In this paper, he has utilized different pretrained CNN models for programmed location and arrangement of infections in a tomato crop leaf. He has additionally used that large number of models on two datasets. The first dataset is a dataset whose pictures are gained in a lab; the second dataset is the field dataset gathered by mobile phones in daylight. In this way, the subsequent information is illustrative of a certifiable circumstance and were henceforth ended up being more trying for different pretrained brain network models. We saw that boundary tuning brings about more precise outcomes than highlight extraction. Moreover, the normal exhibition on the research center-based dataset was 10%-15% better in correlation than the field-based dataset. Initiation V3 was the best performing model on both the datasets.

Rangarajan A K et al.: The creator in this paper examined and dissected the sickness in the tomato plant crop utilizing profound learning models (Alexnet and VGG16 net). For his review he has found and downloaded tomato crop pictures from plant town sites. Out of the 10 classes accessible on the plant town, he has just taken 7 classes (6 undesirable classes and 1 sound class).

Prajapati, H.B Et al: In the review, the perception is essential in light of an information base of 120 pictures of aroused rice leaves separated into 3 preparation bacterial leaf scourge, earthy colored spot, and leaf muck (40 pictures for each class), Authors have changed the RGB pictures to a HSV shading region to become mindful of sores, with a division exactness as much as 96.71% the utilization of k-implies. The investigations have been done to classes the pictures basically founded absolutely on more than one combo of the separated qualities (surface, shading and shape) the utilization of Support Vector Machine. The flimsy spot of this approach is made in a gentle exactness got of 73.33%. Truth be told, the picture extraordinary changed into decreased at some stage in the division stage, at some stage wherein a couple of openings have been produced inside jumble segment, which might be a rationale in the low-class precision. Also, leaf filth is misclassified with a precision of forty%, which calls for various types of capacities to upgrade results.

Kerkech, M et al: The creator in this paper utilizes over the ground pictures, fully intent on recognizing sickness signs and indications in grape leaves [9]. Creators have utilized CNN technique with the guide of utilizing seeming a pertinent combination of picture capacities and shading regions. For sure, after the acquisitions of RGB pictures the utilization of UAV at 15 m stature. The pictures had been changed into unmistakable colorimetric regions to part the profundity information from the chrominance. The shading regions utilized on this examine had been HSV, LAB and YUV, further to the extricated plants files (Excessive Green, Excessive Red, Excessive Green-Red, Green-Red Vegetation Index, Normalized Difference Index and Red-Green Index). For grouping, they have utilized the CNN variant Net-five with four result classes: soil, sound, excited and helpless against contamination. The form has been analyzed on a few combos of enter insights and 3 fix sizes. The palatable outcome transformed into got with the guide of utilizing joining ExG, ExR and GRVI with a precision of 95.86% on sixty 64×64 four patches.

X. Cheng et al: Recently, profound getting to realize methods had been executed in sorting out plant disease broadly. Cheng et al. utilized ResNet and AlexNet to find horticultural nuisances. At the equivalent time, they performed near tries different things with SVM and BP brain organizations; at long last, they were given the excellent exactness of 98.67% through method of method for ResNet-101.

Ferreiraa et al.: applied ConvNets to complete weed recognition in soybean crop photos and arrange those weeds among grass and broadleaf. The great precision they performed is 99.5%. Sladojevic et al.: built a profound Convolutional brain local area to regularly order and find 15 classes of plant leaf infections. In the meantime, their variant transformed into capin a situation to separate vegetation from their environmental elements. They were given a mean precision of 96.3%. Mohanty et al. [21] talented a profound Convolutional brain local area fundamentally based absolutely at the pretrained AlexNet and GoogLeNet to find 14 harvest species and 26 infections. They played out an exactness of 99.35% on a held-out investigate set. Sa et al.: proposed an extraordinary strategy to natural product location through method of method for the utilization of profound Convolutional brain organizations. They customized Faster Region-essentially based absolutely CNN (Faster

R-CNN) rendition, by means of switch getting to know. They were given the F1 rating with 0.

4. EXPERIMENT EVALUATION

System Configuration for Experiment

Experiments were run on a Google Compute Engine instance named Google Collaboratory (Colab) [20] as well as a local machine Intel with configuration (Intel(R) Core (TM) i3-3220CPU @ 3.30 GHz, RAM 16 GB). The notebook provided by the Google colab is based on Jupyter which works as Google docs' object. Apart from it, The Jupyter notebook is having all the necessary libraries for machine learning and deep learning such as Tensor Flow, Keras, Matplotlib, numpy, pandas. Colab operates under Ubuntu 17.10 64 bits and it is composed of an Intel Xeon processor and 8 GB RAM.

Data Set Description

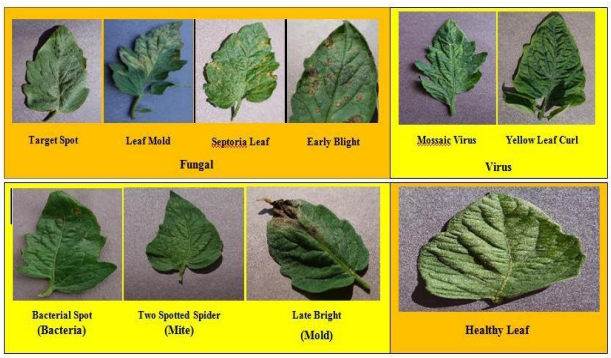

Figure 2 Healthy and unhealthy sample data set images of Tomato crop
(Data has been taken from plant village available at http://www.plantvillage.org)

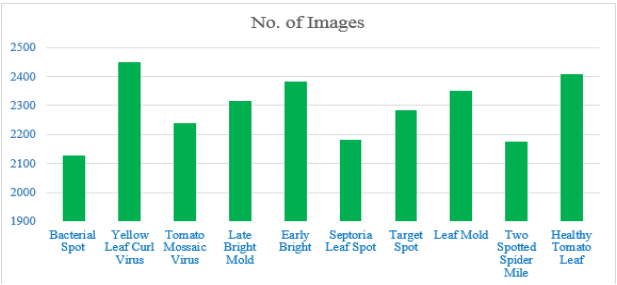

Figure 3 Shows different number of images of healthy and unhealthy tomato crop species belongs to different classes and subclasses

In our experiment we have used a dataset which has been published by (Nouaman Lamrahi et at., 2019). It is open access repository available in http://www.kaggle.com/noulam/tomato website. This web site contains more than 40,000 images that include pepper, potato and tomato. We have extracted only 22912 images of healthy and unhealthy tomato. The figure-3 has shown some examples of unhealthy and healthy images and Table-1 will show the detailed description of our dataset. The dataset contains 22912 images. All the images were divided into ten different classes, out of those 22505 images are unhealthy images (bacterial spot, early blight, leaf mold, septoria leaf spot, target spot, two-spotted spider mite, late bright mold, mosaic virus, and yellow leaf curl virus) were divided in 9 different classes and 1 class of healthy images comprised of 2407 images

Preprocessing

Resizing & Normalization

Data normalization is an important step which ensures that each input parameter (pixel, in this case) has a similar data distribution. This makes convergence faster while training the network. Data normalization is done by subtracting the mean from each pixel and then dividing the result by the standard deviation.

Augmentation

1. Another common pre-processing technique involves augmenting the existing data-set with perturbed versions of the existing images. Scaling, rotations and other affine transformations are typical. This is done to expose the neural network to a wide variety of variations. This makes it less likely that the neural network recognizes unwanted characteristics in the data-set. For our dataset we have used following factors for augmentation.
2. Rotation_range=25, width_shift_range=0.1, height_shift_range=0.1, Shear_range=0.2, zoom_range=0.2

Experiment

Eight pretrained CNN model were investigated that were originally trained on ImageNet data set to classify tomato leaf images. The below table presents the summary of parameters (Batch Size (BS), Learning Rate (LR), Epoches (E), Loss Function (LF), Optimizer (OP)) for classification in experiment.

Table 1 Shows different number of images of healthy and unhealthy tomato crop species belongs to different classes and subclasses

Class	Unhealthy					Heal
Sub Classes	Bacterial	Vir us	Mold	Fun gal	Mit e	thy
	Bacte rial Spot *(2127)*	Yell ow Leaf Curl Viru s *(2451)*	Late Brigh t Mold *(2314)* *463+1851*	Earl y Brig ht *(2382)*	Tw o Spo tted Spi der Mit e *(2176)*	Heal thy Crop s of Tom ato *(2407)*
		Tom ato Mos saic Viru s *(2238)*		Sept oria Leaf Spot *(2181)*		
				Targ et spot *(2284)*		
				Leaf Mol d *(2352)*		
Total Number of Tomato Crop images (Healthy + Unhealthy) = 2407+ 20505=22912						

Table 2 source of image dataset and summary of images for training-testing

Database	Name of Class	Total Number of Images/Class	Total number of images for training dataset	Total Number of image s for testing dataset
Plant Village	Bacterial spot	2127	1701	426
	Yellow Leaf Curl Virus	2451	1961	490
	Tomato Mossa c Virus	2238	1790	448
	Late Blight Mold	2314	1851	463

	Early Blight	2382	1906	476
	Septoria Leaf Spot	2181	1745	436
	Target spot	2284	1827	457
	Leaf Mold	2352	1882	470
	Two Spotted Spider Mite	2176	1741	435
	Healthy Tomato Crops	2407	1926	481

Table 3 Summary of Parameters for Classification Model

Batch Size (BS)	16
Learning Rate (LR)	1e-3
Epoches	10
Loss Function	BCE
Optimizer	ADAM

Performance Measurement

To run the experiments across the train-test splits, we can use any combinations of training-testing set distributions. To run our experiment, we have used 80-20 (80% data used to train the model 20% data used to test the model).

Table 4 Performance Matrix

Performance Matrix	Procedure	Equation Number
Accuracy	$\frac{TP+TN}{(TP+FN)+(FP+TN)}$	Eq-1
Sensitivity	$\frac{TP}{(TP+FN)}$	Eq-2
Specificity	$\frac{TN}{(TN+FP)}$	Eq-3
Precision	$\frac{TP}{(TP+FP)}$	Eq-4
F1-Score	$\frac{2*TP}{(2*TP+FP+FP)}$	Eq-5

TP (Number of Images correctly classified healthy leaf images), TN (Number of Images correctly classified unhealthy leaf images), FP (is the misclassified healthy images), FN (Misclassified unhealthyimages)

5. RESULT

In this research study, we have conducted one experiment for tomato leaf images and the relative performance for eight different CNNs for the one classification schemes is shown in table 5. From the table, it is clear that all the pre trained model performance was very well in identifying healthy and unhealthy tomato leaf images in ten-class classification problem.

Table 5 Classification

Classification	Model	Overall	Weighted			
		Accuracy	Precision	Sensitivity	F1-Score	Specificity
Ten class Classification	Resnet	92.85	92.76	92.78	92.73	99.54
	Resnet 18	96.77	96.76	96.97	96.67	99.62
	Mobile Net	97.4	97.81	97.91	97.27	99.72
	DenseNet201	98.11	98.13	98.23	98.13	99.67
	Imagenet	88.12	93.24	93.44	93.67	97.23
	Inceptionv3	97.49	97.41	97.38	97.43	99.92
	VGG16	92.14	95.41	95.52	95.34	99.23
	VGG19	94.92	96.22	96.56	96.67	99.58

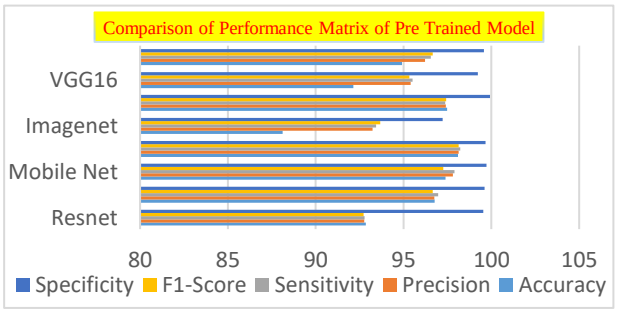

Figure 4 Comparison of Performance Matrix (Specificity, F1-Score, Sensitivity, Precision, Accuracy) of Pre-Trained Model

6. CONCLUSION

In this paper, we have first identified the growth and production of tomato required. The tomato is the third largest crop in India, so the early detection of crop disease will play crucial role of identifying and monitoring the production of the crop. Secondly, we have studied different architecture/models used to identify the tomato crop disease. For the same we have studied several research papers. Third we have chosen different deep learning models ImageNet, ResNet, ResNet18, DenseNet201, MobileNet, VGG 16, VGG19 and inceptionv3 to identify tomato crop disease. We have used Google colab where we setup the environment and perform all the experiments. We have downloaded the dataset of tomato crop from plant village and perform all the experiments. As the images in each class are unbalanced so first, we have applied normalization and data augmentation technique to balance the images of each class. We have analyzed that for ten class classification DenseNet201has given 98.11% accuracy and the inceptionV3 has given 97.39% accuracy. We have compared our result with machine learning algorithms (SVM and random forest) and we found that deep learning models are giving better results as compared to machine learning. Still, we think that there are many challenges in the field of agriculture that need to be identified for further studies to improve the agriculture economy.

REFERENCES

[1] (FAOSTAT) food and agriculture organization of United States, database 2019.

[2] M Nagaraju M et al. 2020 Systematic review of deep learning techniques in plant disease detection International Journal of System Assurance Engineering and Management **11** 547–60

[3] Das Siddharth [Internet]. Medium [updated 2017 Nov 16; cited 2020 Sep 21].

[4] Masri Ali [Internet]. MarkTechPost [updated 2019 Jun 14; cited 2020 Sep 21].

[5] Hiary Het al. Fast and Accurate Detection and Classi_cation of Plant Diseases, International Journal of Computer Applications 17 (2011) 31-38.

[6] Akhtar A et al. Automated Plant Disease Analysis (APDA): Performance Comparison of Machine Learning Tech402niques, in: 2013 11th International Conference on Frontiers of Information Technology, fIEEEg Computer Society, 2013, pp. 60-65.

[7] Mokhtar U et al., SVM-Based detection of tomato leaves diseases, in: Advancesin Intelligent Systems and Computing, volume 323, Springer, 2015, pp. 641-652.

[8] Sannakki S.S et al., Diagnosis and Classification of Grape Leaf Diseases using Neural Networks, in: Com411 puting, Communications and Networking Technologies (ICCCNT), 2013 Fourth International Conference on, IEEE, pp. 3-7.

[9] A. Breitenreiter A et al, Deep Learning, Nature 521 (2015) 2015.https://plantvillage.psu.edu/topics/tomato/infos

[10] http://www.kaggle.com/noulam/tomato

[11] Tian H et al., 2020 Computer vision technology in agricultural automation-A Review Information Processing in Agriculture 7 1–19.

[12] Kamilaris A et al., 2018 Deep learning in agriculture: A survey Computers and