Tomato leaf disease detection using deep learning algorithm

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Abstract: Convolutional Neural Network has actually considerably increasing the precision of image acceptance methods within the many years which are present. Most pretrained training that is actually deeply are offered for usage and this also studies have used one particular strong training unit particularly, ResNet-152 for finding leaf disorders suffering in tomato vegetation. The transfer training method is actually used within the tomato-leaf diseased facts set by fine-tuning the hyper-parameters and also the levels on the ResNet-152 design. The dataset consists of 18345 photos of tomato dried leaves infected with ten tomato conditions. The ResNet-152 this is certainly fine-tuned unit an reliability of 99% that will be seen to be a lot better than the present different versions. Symptoms and parts which are harmful tomato foliage had been recognized making use of photographs seized through CCTV digital cameras from inside the areas. This design may end up being a good instrument for growers for very early discovery of leaf ailments and receiving a give that will be great.

Index Terms – **Computer Vision, Convolutional Neural Network, Deep Learning, Image Processing, Plant Disease Detection**

I. INTRODUCTION

Plant leaf diseases are available in a variety of kinds that will trigger financial, personal, and results that will be environmental. Consequently, fast and recognition this is certainly efficient of diseases is important to avoid losings in farming goods production and produce. Herbal illness discovery is usually complete manually. Specialists perform these methods, which start a evaluation this is certainly aesthetic advancement to a great lab style. These methods which are conventional usually time-consuming and difficult. This means that, it's become important to utilize image operating and device learning how to identify ailments immediately. Contained in this situation, strong training is the ideal answer to recognize ailments in real time atmosphere.

Tomatoes become certainly one of India's big vegetation. In 2012, India is rated next with respect to tomato use rate, having a use of 16,637,520 kg. Through the assessment can recognize that, tomato consumption speed in Bangladesh amounted to 246,385 kg, 43,121,765 kg in China, 868,091 kg in Pakistan and 78,717 kg in Sri Lanka. The significance of tomato manufacturing towards the economic climate that is indian revealed from the expanding patterns.The initial step in avoiding and regulating herbal diseases would be to recognize all of them easily and truthfully. Very early recognition decreases the level of damage complete and enables on the cheap cures which happen to be high priced. Cures for farming ailments which happen to be wrongly determined could possibly be not successful and sometimes even detrimental to plant life. In farming, item detection and category made usage that will be substantial of discovering technologies. It requires, fresh fruit counting, harvest produce evaluation, area dirt wetness prediction, elements prediction, harvest infection recognition, and various other production strategies etcetera [1, 2].

These studies report was organized the following: part 2 explained the report about literary works linked to the place disorder recognition. Part 3 reveals the convolutional system this is certainly neural transfer reading design and also the details regarding the datasets employed for these studies like their labeling and course. Area 4 explained the sum of the outcome and gratification for the unit. Point 5 concludes the task.

II. RELATED WORKS

This area provides a study on most recent analysis services posted on harvest disorder discovery utilizing strong understanding methods. The Cognitive Fuzzy C-Means Algorithm (CFCM) means is employed to anticipate the place disorders instantly. The suspected part in harvest and vegetation such grain and fruit forest try recognized employing a CAD system-based graphics research techniques contained in this means. The sounds decrease therapy when you look at the graphics ended up being sang making use of the Cross Central Filter (CCF) means, plus the item recognition techniques had been sang with CFCM formula to tell apart the unhealthy leaf neighborhood through the regular section of the leaf. SVM classifiers centered on Quad Programming can be used for category. The Mean Squared Error will be the notion of difference amongst the genuine price and expected benefits. The Gaussian spatial hookup try examined when it comes of mean, difference, and Gaussian purpose for every single class [3].

This has been suggested to cultivate a device vision-based professional system for pinpointing jackfruit disorders. K-means clustering segmentation can be used contained in this way to get a hold of disease-affected parts of the jackfruit image and draw out features from all of these areas. From then on, the ailments become grouped making use of the haphazard woodland way. All in all, 480 photographs comprise grabbed in Bangladesh because of this dataset. 90% reliability had been reached. Misunderstandings matrix put as being a appliance for assessing efficiency[4].

A image category method was developed for area and blight unhealthy leaf imagery from four unique herbal kinds. The traits had been analytical consistency properties produced through the Grey-Level-Co-occurrence-Matrix (GLCM). The illness recognition precision had been discovered to be 74%. Each function's effects amount is determined with the graphics ready's common deviation [5]. Using a 9-layer Deep Convolutional Neural Network design to identify herbal diseases is actually investigated. When you look at the proposed design's pooling level, the maximum pooling treatment was actually used. Several harvest types such as for example fruit, tomato, grape, cherry, potato, soybean, peach, and blueberry were utilized within an enhanced dataset of 61,486 photos and done 3000 epochs during education period. The common tests precision because of this design is 96.46 per cent [6].

A research study predicated on convolutional sensory communities happens to be suggested when it comes down to independent discovery of place disorders. Making use of three CNN systems, experts produced two baseline networks, a Triplet system, along with a strong adversarial Metric Learning (DAML) method for herbal infection discovery. PlantVillage Dataset was applied for your analysis which determined 26 disorders of 14 various harvest. Coffee Leaf Dataset additionally accustomed produce the dataset. These formulas had been created after are taught for a large dataset then fine-tuned to spot and foresee the condition coming from a restricted range artwork (between 5 and 50 per disorder). This product has actually attained 99% reliability rates [7]. Image acceptance unit recommended by using Convolutional Encoder Networks, an innovative new way of discovering harvest ailments was developed. Various convolution filters like 2×2 and 3×3 were utilized. Last reliability hit 97.50per cent [8].

Convolution sensory companies (CNNs) happened to be employed in purchase to get services from grain leaf imagery within this learn, immediately after which the SVM strategy was utilized to classify and anticipate the specific condition. The dataset includes 8911 photographs various diseases has, rice shoot, microbial place, grain sheath blight and grain roentgen move leaf place. The precision for the CNN in conjunction with SVM product try 96%, whereas the traditional CNN product try 84.52 %, based on the test outcomes [9]. Introduced a research for discovering grain condition by combining the quicker R-CNN and FCM-KM formula. To reduce effects of complex credentials using the identification of target blades in graphics, it implements a two-dimensional Otsu limit segmentation method this is certainly quicker. Dataset consists of 3010 imagery and three tuition of grain disorder. It demonstrates a typical reliability of 97.2% [10]. Strong function established ailments forecast of grain leaf photos utilizing SVM process discussed; Deep attributes become along with SVM as well as a exchange discovering strategy. From an farming insect databases, 5932 on-field images of four types of grain leaf disorders comprise acquired. Having an F1 rating of 0.9838, the strong ability of ResNet50 with SVM carries out much better [11]. Tukey's sincere importance examination was utilized to evaluate the categorization systems better. Sunflower leaf ailments recognition using image segmentation centered on particle swarm optimization introduced. Mcdougal produced a image segmentation method considering PSO for ailments detection in sunflower herbal foliage, that has been winning in discovering and categorising the problems. The color co-occurrence means got used to pull properties. An average reliability attained 98%[12]. Another research introduced making use of sensory community formula which explains a cycle-consistent adversarial networking deep training design had been used utilizing the standard graphics enhancement methods to enhance information due to insufficient image facts brought on by the arbitrary incident of fruit diseases. To generate unique tuition datasets, photographs were arbitrarily selected through the dataset including 700 images obtained from real time industries. This unit shows The F1 rating is actually 0.816, as the IoU rating for the whole dataset are 0.675. 95.57 percentage precision ended up being attained. DenseNet dramatically escalates the utilization of functions when you look at the sensory system and boosts the YOLO-V3 product's discovery show [13].

To create a crossbreed prediction design, scientists put three vibrant optimization formulas: Gravitational Search Algorithm (GSA), Artificial Bee Colony Algorithm (ABC), and Differential advancement Algorithm (DE) . This product suggests that it enhances the precision and increase of pinpointing optimum SVM factor standards The sensory circle's body weight vector and biases are fine-tuned via smart task for standard generalised features [14].. This Feed Forward Neural Network concern is answered by using ELM formulas based on the program's targets [15]. Serious Learning device formulas need changed present sensory networking sites having an reliability f 94.1% by good tuning the different variables such as for instance loads and biases within the concealed level [16].. The breakdown of strong studying sensory networks try recommended with a specialist which experiences many facets of strong training sensory system architectures to get yourself a best product to predict malignant tumors condition, professionals assessed during the RNN, FNN, and CNN types Created a summary with CNN outperforms the FNN by 43 % plus the RNN by 25 % in forecast [17]. The specialist proposed plan which utilizes the SVM method for category and utilizes the CNN way of ability removal and system education [18]. To categorize artwork better, a strong discovering image category strategy shows a DenseNet design, which hit the precision standard of 99percent [19].

TABLE I.   SUMMARY OF RELATED WORK ON PLANT DISEASE DETECTION

Author and Year of Publication	Algorithm Used	Performance
Sampathkumar S et al. [3] (2020)	Cognitive Fuzzy C-Means Algorithm	83.47% Accuracy
Md. Tarek Habib et al. [4] (2020)	K-means clustering	90% Accuracy
Aditya Sinhaa et al. [5] (2020)	Grey-Level-Co-occurrence-Matrix	74% Accuracy
Geetharamani G et al. [6] (2019)	DCNN	96.46% Accuracy
Ahmed Afifi et al. [7] (2021)	CNN	99% Accuracy
Aditya Khamparia et al. [8] (2020)	Convolutional Encoder Networks	97.50% Accuracy
Feng Jiang et al. [9] (2020)	CNN, SVM	CNN with SVM model : 96.8%, CNN model : 84.52% Accuracy
Guoxiong Zhou et al. [10] (2019)	Faster R-CNN and FCM-KM algorithm	97.2% Accuracy
Prabira Kumar Sethy et al. [11] (2020)	SVM, Transfer Learning	98.38% Accuracy
Vijai Singh [12] (2019)	Particle swarm optimization	98% Accuracy
Yunong Tian et al. [13] (2019)	Cycle-consistent adversarial network, YOLO v3	95.57% Accuracy
J. Samuel Manoharan [15] (2021)	ELM Based	94.1% Accuracy
Milan Tripathi [19] (2021)	Deep Learning – DenseNet Model	99% Accuracy

The research tend to be enough to show that strong acceptance that will be learning-based, specifically CNN, are of help inside the industry of farming. But, numerous weaknesses and troubles stay in the preceding researches, like the recognition price becoming best for particular examples under some ailments. Some details inside the product this is certainly symptomatic maybe not perfect, in addition to instruction algorithm's convergence energy try bad. The purpose of these studies will be establish most precise CNN-based design for automatic place condition recognition this is certainly farming. The standing of leaf photographs with changing experiences on big graphics sessions is not generally investigated since real-world artwork may differ considerably when it comes to light ailments, graphics high quality, positioning, along with other aspects [20], [21].

III. PRPOSPED MODEL FOR TOMATO DISEASE DETECTION

This part clarifies the strategies included in this considerable analysis, such as the design additionally the recognition treatment. Varying elements, such as for example weather situation, setting off circumstances, dampness, nutritional elements, fertiliser, drinking water administration, and farming ailments, might impact tomato plant disorders.

3.1 Convolutional Neural Network

Convolutional Neural Network can be a formula this is certainly powerful is obviously learning function convolutional organizations instead of common matrix multiplication. A residential district this is certainly convolutional might be physical usually takes an understanding visualize, aspects of the layouts, and differentiate included in this. Convolutional Neural Network amounts have actually really neurons made in three measurements perimeter that will be like leading, and level. Making use of tension that's needed is a method that'll be physical willing to exactly capture the spatial and short-term collaboration within a visuals. It provides the chance to discover characteristics out which features methods becoming old filter systems. As a result, most applications which can be precise up on understanding photos. CNN is among powerful that has been system this is certainly efficient working together with photos in comparison to most ways. at components

opportunity that will be several is obviously genuine from comments artwork which have been ideal for illustrations class together with other computer image applications. Figure 1 shows the structures of a Convolutional physical that will be really typical Network [22].
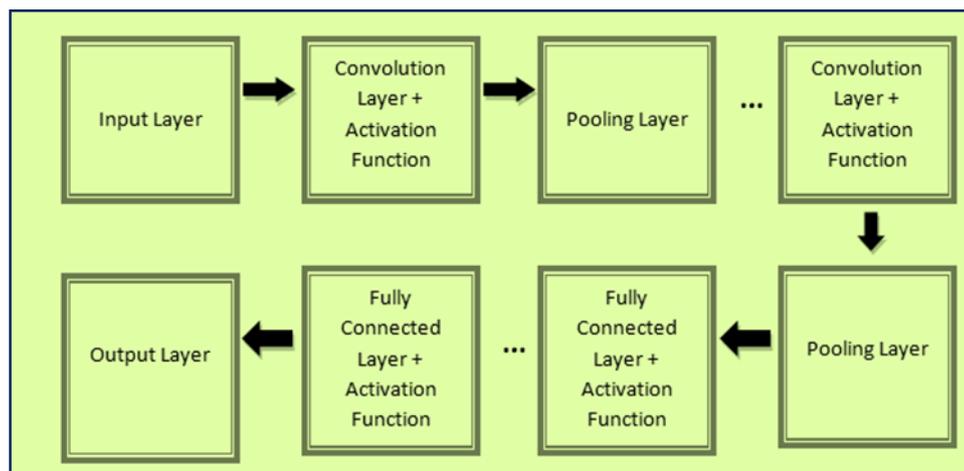

Figure 1. Layers of Convolutional Neural Network

3.2 Transfer learning

Transfer learning can be an thoroughly utilized method for using previous obtained understanding to fix a certain difficulty in one single area along with a brand new test within a associated one. Transfer understanding is really a strong discovering method enabling a CNN taught for starters task are used for the next task by way of a data set that will be brief. For the reason that training types relax and take a tremendous amount of the time and computational info to coach large details, and obtaining a big labelled dataset for design classes is just a projects this is certainly intricate [23]. This is why, exchange training try slowly getting the method this is certainly favoured and it's also getting used in practice. That is apparently, practices that rely on a system that are pre-trained entirely utilize the education facts to calculate the details associated with the best category levels [24]. Every one of the system levels comprise fine-tuned, and backpropagation optimization through the communities being pre-trained carried out.

3.3 Dataset description and metrics evaluation:

For classes and tests uses, open-access dataset from PlantVillage were used, which is made of 14,822 healthier and infected tomato-leaf files thought about for creating a tomato illness category design. Desk 2 reveals the knowledge that will be intricate of that has been extracted from plantvillage dataset with this analysis. The databases includes graphics of healthier and bad dried leaves from ten categories being unique.

TABLE II.   DETAILED INFORMATION OF DATASET (PLANTVILLAGE PUBLIC DATASET)

Class	Disease Name	No. of Images
1	Bacterial Spot	2127
2	Early Blight	952
3	Late Blight	1781
4	Leaf Mold	904
5	Mosaic Virus	325
6	Septoria Leaf Spot	1723
7	Spider Mites	1628
8	Target Spot	1356
9	Yellow Leaf Curl Virus	4032
	Total	14,828

All tomato-leaf photos happened to be sectioned off into two organizations: tuition evaluation and dataset dataset. The dataset consists of 18,345 photos of coaching and 4585 photographs of examination emerge all of our tests. Some files obtained from the dataset which have been provided in Figure 2.
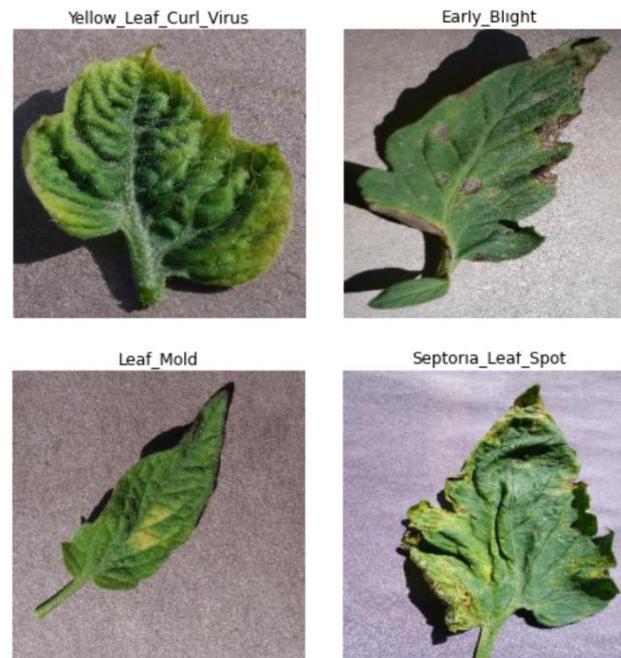

Figure 2. Extracted images from PlantVillage Public Dataset

In relation to creating a graphics this is certainly profitable, applying graphics enhancement techniques is essential. Regardless of if datasets contain much more range education files, the variety may possibly not be adequate to produce an product that will be appropriate. Data argumentation is just a approach that is utilized to boost the real range graphics within a dataset that has been proven to considerably boost reliability associated with design. To prevent troubles like overfitting, deeply discovering formulas constantly be determined by big datasets. This can be a shield that will be typical creating formulas for wider utilize. Data meeting may well be a time consuming treatment which could require the effective use of domain name authorities for labelling opportunities. Using enlargement methods would have been a remedy when it comes to issues that is above-mentioned. Augmentation practices can be utilized for improving the photographs which can be present. Within this papers, Data enlargement draws near used to stabilize the circulation of several sessions of photos: (i) width, (ii) peak, (iii) zoom, (iv) rotation, (v) horizontal flips, (vi) straight flips are used on working out dataset.

Within this substantial studies, Adam Optimizer has been utilized. In comparison with SGD optimizer, Adam Optimizer shows a rate that will be high of. Accuracy stage increased from 87% to 99per cent. Increasing group size improvement being also revealing the accuracy, batch size 10 to 128 provides variation during the forecast levels. Away from 20 epochs trained, in 7th epoch revealing the betterment in consequences. Continued okay tuning with epochs provides the result that is expected. Tests were finished utilizing 10 sessions which can be various 9 tomato diseases. Wearing a community that will be sensory, activation performance establish nonlinearity for the linear altered feedback. They have a influence that will be vital neural network results and classes duration, and so the choice of the activation function try crucial with regard to neural system with much better overall performance, much less education energy, and decreased reduction. The significant obstacle confronted by sigmoid activation features try disappearing issue that will be gradient. Softmax activation features is employed for multinomial logistic regression, therefore utilized in the production layer of a multi-class classification system this is certainly sensory. Softmax classifier uses the reduction this is certainly cross-entropy. Without deleting data factors from the dataset, Softmax normalisation decreases the effects of outliers when you look at the data. Since this activation function offers one price for every single node within the productivity covering associated with the sensory circle, it'll incorporate chances this is certainly finest for any targeted courses. So, Softmax activation function has been used instead of sigmoid in this analysis.

ReLU (Rectified Linear Unit) activation operate applied in hidden layer for this model. Once the input towards the ReLU features is good, the gradient can run across different layers, producing systems that are deep ReLUs simpler to optimize than networks with sigmoid or Tanh products. When working with ReLU during the undetectable layers, in the event that neuron's price is 0 or even a worth this is certainly bad the neuron will not shoot, causing just a couple neurons becoming activated. These neuron loads and biases may not be upgraded in the back propagation phase, resulting in a dying ReLU problem because of this. The process of dying ReLU concern pushes neuron into never ever discharged says and it will lead for disappearing concern this is certainly gradient. ReLU activation function will output the input it's going to generate 0. ReLU ranges between 0 and infinity since it is when the importance is positive; or else.

Categorical Entropy may be the reduction features used within this unit for multiclass classification issue. Digital entropy is utilized to classify for the class this is certainly solitary. Categorical Entropy is used to examine two probability distributions and assess the essential difference between them. Table 3 presents the summary of layers used in the product that will be suggested.

TABLE III.   LAYERS USED IN PROPOSED MODEL

Input Layer	8X8X2048
Convolutional Layer	8X8X512
Padding	10X10X512
Output Layer	8X8X2048
Total Parameters	60,390,658
Trainable Parameters	56,430,338
Non Trainable Parameters	3,960,320

IV. EXPERIMENTAL RESULT

This report experimented a novel model for pinpointing 9 tomato this is certainly various disorders utilizing ResNet 152 after building a comparative assessment between some other exchange training design includes AlexNet and VGGNet. The AlexNet design was introduced in 2012 by Alex Krizhevsky. It offers 8 layers and ReLu activation purpose has been utilized. Since this model's level is really low, it struggles for discovering functions from image datasets. When compared to more types, we can discover that obtaining greater reliability outcomes takes longer in this circle. Aesthetic Geometric Group or VGG is a Convolutional Neural Network buildings, that was launched in 2014. As opposed to a single-layer this is certainly convolutional a top kernel size, the VGG system presents the notion of combining most convolution layers with decreased kernel sizes. This unit is afflicted with the vanishing gradient complications, which had been discovered to be a drawback that is significant. ResNet ended up being applied in 2015, also it resulted in a increase this is certainly considerable reliability along with a significant upsurge in increase. ResNet discover because the solution for gradient vanishing issue, which had been the nagging issue faced by VGGNet. The design built using the ResNet architecture additionally displayed a recognition this is certainly very little, indicating that no over-fitting took place during classes. Feedback coating, Convolution production and layer covering has been added using the product. 60,390,658 parameters were used within this experiment. Cushioning has been added with convolution level since it will properly boosts the number of image that the convolutional system that will be neural analyse. Through the research learned that ResNet 152 design perform well compare to one other two systems.

Table 4 presents the test result of the best design that is performed ResNet 152. As shown in desk 5 and Figure 3, Identified changes in precision level according to the changes in number of epochs. Accuracy portion was increased through the increment in number of epochs ResNet152 this is certainly suing Model.

TABLE I.   RESULT OF PROPOSED MODEL

Model	Accuracy	Validation Accuracy	Epochs	Batch Size	Validation Loss	Average Time
ResNet 152	0.99	0.9510	20	80	0.1891	134s/step

TABLE II. SUMMARY OF PERFORMANCE USING RESNET 152 MODEL IN EACH EPOCHS

No. of Epochs	Performance in Accuracy
5	91
10	91.1
15	95.1
20	99

The suggested model has been implemented Keras that will be making use of so that as backend. For training the model, Google Colab has been used. Somewhat for the CPU, the GPU enhances the unit's handling speed. The results is stored in the Google Drive. The show metrics assessed in this scholarly learn become here.

- Performance reliability: The percentage of imagery that were effectively classified for the wide variety that will be total of.

- Loss function: exactly how effortlessly the data is actually modelled from the design
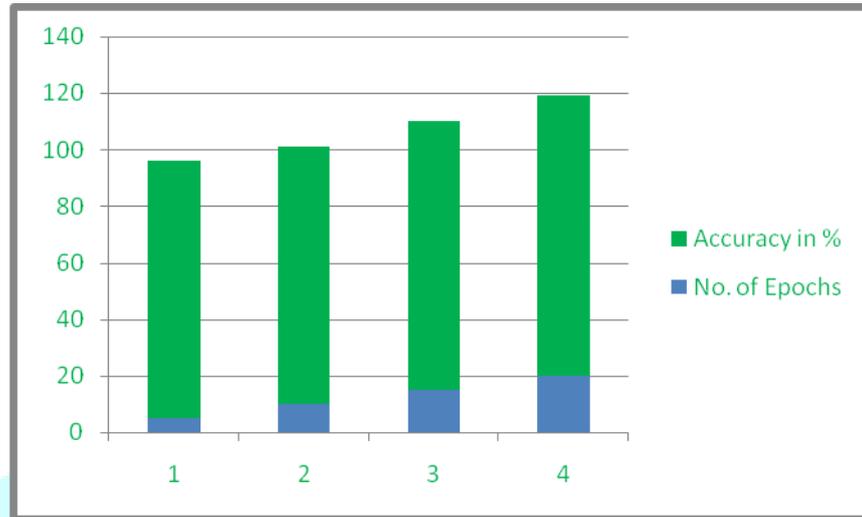
- energy needs: Per epoch for practise each unit.

Figure 3 Analysis of Performance (Accuracy) in each epochs

The recommended ResNet 152 design for detecting the severe nature in tomato leafs is taught with Keras and Tensorflow in google colab. ReLu Activation purpose happens to be applied. Max Pooling has been utilized with convolutional level. Cushioning shall become beneficial to adjust the dimensionality on the image efficiently. Thus forward included cushioning when you look at the level with 10 X 10 proportions that is kernal. This unit was taught with 20 epochs to get to the precision this is certainly increased. Figure 4 presents the plots of validation and training reliability and loss in ResNet-152 product during tuition and examination methods. X Axis shows the actual amount of epochs for instruction stage and Y Axis shows the portion of reliability degree. Classes and recognition reliability has been incremented through improving the genuine wide range of epochs. Similarly tuition and recognition control happens to be decremented through enhancing the correct amount of epochs. Through the above analysis we can understand that the performmance of each model is increased according to the changes in number of epochs. Performance can be measured using accuracy percentage. The hyper-parameters this is why, it really is showed that people can contact larger precision degree by okay tuning. A validation was confirmed by this product loss in 0.1891.
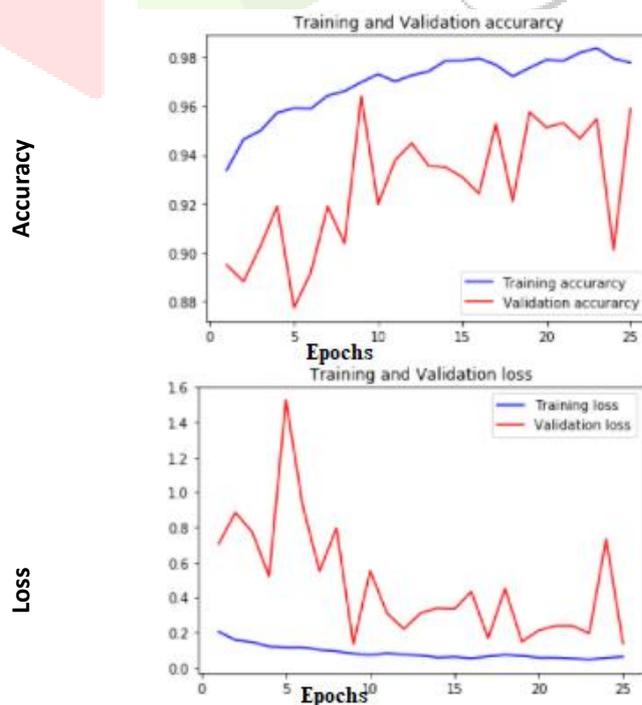

Figure 4 Training and Validation Accuracy and Loss

Figure 5 and Figure 6 shows the condition this is certainly forecast Leaf Spot and Late Blight diseases respectively. A predicted class and portion of probability disorders are demonstrated within our tests, at the end of the process. Model shows the prediction of tomato-leaf disorder accurately.
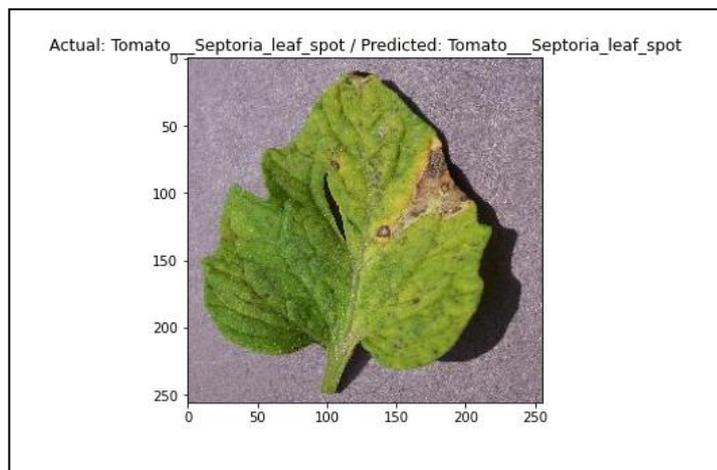

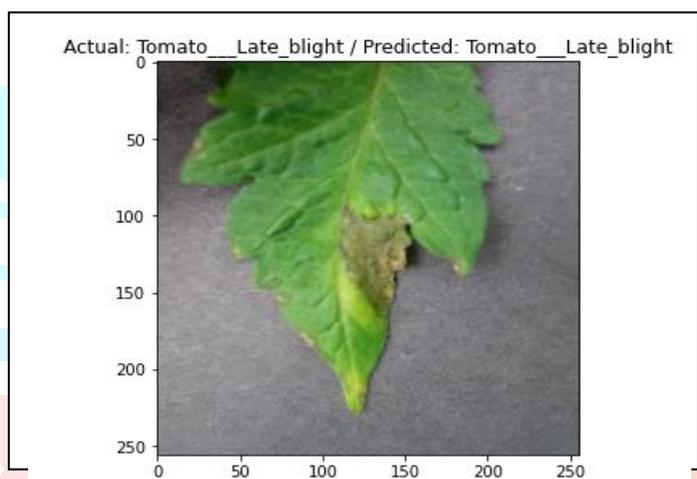**Figure 5.** Predicted Disease: Tomato Septoria Leaf Spot.

Figure 6. Predicted Disease: Tomato Late Blight

This paper makes use of the nine typical types of tomato-leaf conditions to evaluate the Transfer Learning algorithm with Resnet-152 concept. These tomato-leaf artwork have been created from location community dataset this is really community. In this test training this is certainly further such as AlexNet and VGGNet instructed over 30 epochs using a knowing costs of 0.0001. The proposed concept received an accuracy of 99% in connection with direction set, which will likely be greater than in comparison to previous styles, because of modification from the convolutional layers getting predicated on top features of tomato leaf imagery that are illness. The systems took place to right up be trained to 20 epochs and set the batch sizes to 80. ResNet 152 product demonstrates 99% validation and dependability dependability of 95per cent. As present in dining table 6, AlexNet is clearly traned by having a united party proportions of 128 and 56,884,612 parameters and could achieve the group 95.81%. VGGNet design became uses the cluster dimensions of 32 and 165,734,212 parameters and obtained an precision of 96.19 percent.Even though VGGNet demonstrates larger overall performance than AlexNet layout, the evaluation with assorted CNN companies feature AlexNet, VGGNet and ResNet 152; ResNet 152 outperforms the result. All assessments did through google colab structure. Table 6 demonstrates the batch proportions put, a number of variables a dependability that will be;nd by each model. Figure 7 gives the accuracy comparison advantage review of AlexNet, VGGNet and ResNet 152 things.

TABLE III.   COMPARATIVE ANALYSIS OF DIFFERENT MODEL PERFORMANCE

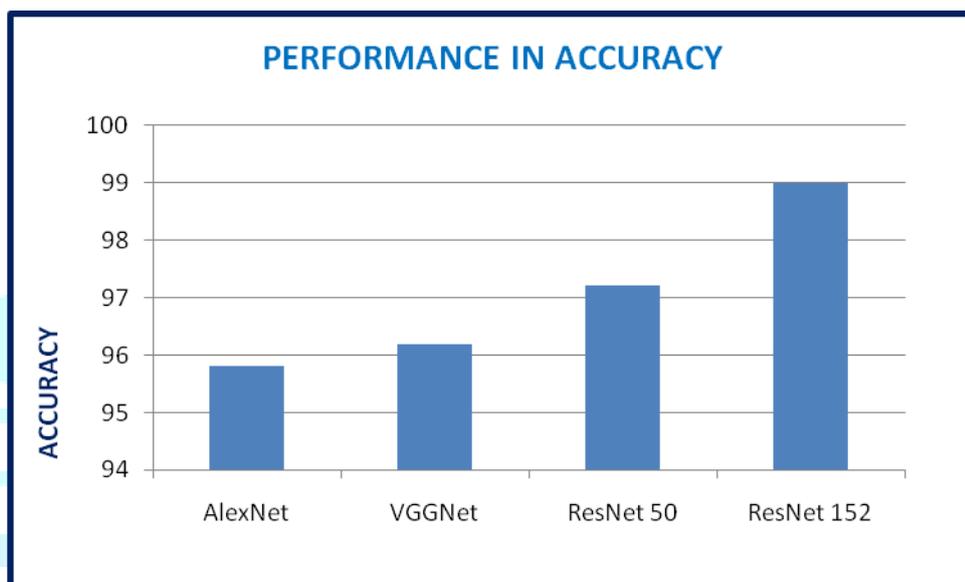| Model	Batch size	Parameters	Accuracy (%)
AlexNet	128	56,884,612	95.81
VGGNet	32	165,734,212	96.19
ResNet 50	80	145,632,174	97.21
ResNet 152	80	60,390,658	99

Figure 7. Accuracy comparison chart with different transfer learning models

This design has become increased through alterations in various parameters. It involves incorporating the sheer number of hidden layers, changing the amount of epochs, switching activation this is certainly various, and using big dataset for instruction and assessment. Accuracy reveals growing whenever education dataset image count improves. We can easily manage to understand visible changes in activation work, and quantity of epochs furthermore leads to caused by reliability principles. In ResNet 152 design, we have used entropy that will be categorical locating the control function. Since we included multiclass within our product, categorical control that is entropy provides better result.

Convolutional Neural Networks' overall performance in object image and detection classification keeps improved considerably in recent years. Most conditions do not show up on the surface that is higher of, but alternatively on some other chapters of the place. Because of this, future graphics exchange activities should seek to catch imagery from a selection of perspectives, essentially in as practical a situation as you possibly can. Further data that will be potential be centered on fine-tuning the variables with the deep discovering model, such as for instance including wide range of layers, modifying how many concealed nodes, plus the activation work.

V. CONCLUSION

This papers provides an move that is increased product making use of strong convolutional structure for tomato infection classification. This unit can understand optimally a amount this is certainly large of information when using the moderate info. The recommended system is analyzed to identify tomato leaf diseases plantVillage dataset that is utilizing. This approach can be used to identify 9 tomato disease classes including Bacterial Spot, Early Blight, later Blight, Leaf Mold, Mosaic Virus, Septoria Leaf Spot, Spider Mites, Target acne, and Yellow Leaf Curl Virus by way of a test that is great of 99% whereas the recognition precision try confirmed 95%. When compared to other exchange studying types include AlexNet and VGGNet and ResNet 50, our proposed model making use of ResNet 152 outperforms in the comparison analysis.

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