A Comparative Study on Plant Disease Detection Using Machine Learning Algorithm

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Abstract

The crop diseases are major problem in agriculture industry that requires an accurate and fast crop disease detection method to prevent and limiting major loss. Many researchers utilize machine learning algorithm to achieve this solution. Majority of the solution either using traditional machine learning algorithm or deep learning-based algorithm. For traditional machine learning algorithm, the algorithm usually used feature extraction algorithm paired with machine learning algorithm such as Support Vector Machine, Logistic Regression and K-Nearest Neighbor. Deep learning-based algorithm utilize either fully connected neural network or use convolution neural network as feature extractor and paired it with machine learning classifier. However, evaluating those algorithms are quite difficult due to different settings in each experiment done in evaluating deep learning-based algorithm and traditional machine learning based algorithm. The purpose of this paper is to evaluate those algorithms with same dataset which is Plant Village dataset to give them fair comparison in performance. The results show that both machine learning and deep learning algorithm achieve great result with the highest accuracy achieve around 97% accuracy.

Keywords: Crop diseases, deep learning, convolutional neural network, machine learning, Support Vector Machine, K-Nearest Neighbor

1. Introduction

Agriculture industry is facing one major problem, which is crop diseases. Due to climate change, crop diseases become deadlier than ever which according to Food and Agriculture Organization of the United Nations (FAO), on 2018 crop diseases account for an estimated 10-16 percent loss of global agriculture harvest [1]. Crop diseases, without some sort of early detection method, will greatly affect the agriculture industry. Current detection method is simply by using naked eye, which expensive and also unscalable method to deploy in large farm. Thus, many researchers are using artificial intelligent and computer vision to detect agriculture disease in agriculture goods. By using artificial intelligence, result can be produced faster, precise, and efficient compare to the human beings that prone to the human error.

. On the current information era, devices around the world has more computing power than ever. Machine learning based solution, which is computably expensive before become more viable nowadays. Thus, many researchers use this opportunity to use machine learning algorithm to classify crop diseases. K-Nearest Neighbour (KNN) and Support Vector Machine (SVM) is ones of the popular machine learning algorithm used in crop diseases classification [2], [3]. The machine learning algorithm usually paired with some feature extraction algorithm. However, this algorithm come with huge drawback which is reliance on pre-processing technique that computationally demanding processing time and required high domain of knowledge [4], [5].

Other popular Artificial Intelligence (AI) algorithm is Convolution Neural Network (CNN). CNN, as name suggest is inspired from biological neural network. CNN consist of various layers, which primally convolution, pooling and fully-connected layer. The first layer in CNN will be convolution layer, which can be followed by another convolution layer or pooling layers. The last layer will be fully connected layer for classification purposes. The main purpose of CNN is to create automated and trained models which greatly reduced human intervention in finetuning an Artificial Intelligence algorithm. These algorithms can take up clusters of data and also employ more data points to increase the accuracy. However, CNN requires a lot of data and a lot more of training time to have an acceptable accuracy [6]. One of the CNN architecture, Resnet50 takes around 14 days to train on ImageNet dataset [6]. And ImageNet itself have thousands of images in their dataset [7].

On the most literature published to overcome agriculture crop diseases, most of the algorithm used are usually machine learning algorithm such as KNN and SVM coupled with feature extraction algorithm such as Gray Level Co-occurrence Matrix (GLCM) and Scale-invariant Feature Transform (SIFT) or by using deep learning algorithm such as CNN to identify crop diseases. Both of this method has its own advantages over the others. However, it is difficult to compare both of this method since different paper tend to have different settings and dataset for their experiment. Thus, they are need for study to evaluate these two different algorithms with same settings and dataset

2.Literature Survey

AI as a tool have become a significant part for solving real problem regarding problems related to prediction and regression. One of the branches of AI is machine learning. One of problem that machine learning algorithm have been applied by researchers is crop diseases classification. In image recognition field, a great data collection is a significant part of the research. One of data collection used by using handheld devices to take images and integrating image processing technique to their methodology [8]. From the Table 1, this technique still leave room for improvement. The summary of literature review for traditional machine learning algorithm in plant disease detection are summarise in Table 1.

A part of deep learning algorithm, CNN is also used for crop disease image classification by the researchers. CNN have no need for image segmentation and feature extraction because of their layers have already fulfil similar role. However, CNN usually need a huge amount of dataset for training purposes. This problem can somehow be mitigated by using transfer learning. One of the researchers that use this method is [9] in order to create a CNN model that can classify crop diseases. Some other researchers are using CNN model that's are trained on different dataset as feature extractor and use machine learning classifier such as KNN and SVM to classify [10]. The summary of CNN based algorithm are summarise in Table 2.

Autho	r Title	Process	Dataset	Result
[3]	Detection of	1. Images in dataset were	Various leaves	Accuracy
	plant leaf	applied with image	images of	with
	diseases using	processing techniques.	banana, beans,	SVM
	image	2.The datasets were	lemons and	95.71%
	segmentation	applied with Green pixel	rose were taken	
	and soft	masking.	using camera.	
	computing	3.Segmentation were used		
	techniques	using GA.		
		4.Color co-occurrence		
		feature were computed.		
		5.Classify using Minimum		
		Distance Criterion and		
		SVM.		
[11]	Rice Blast	1. Images in dataset were	Images of	90%
	Disease	converted using color	paddy leaves	testing
	Detection and	conversion.		accuracy
	Classification	2. K-means clustering were		
	Using Machine	used for segmentation.		
	Learning	3. Extract feature such as		
	Algorithm	Mean Value, GLCM and		
		Standard Deviation		
		4. Classifier used is		
		(Artificial Neural Network)		
[12]	Detection of	Alvin 1 Divel mesking were used	Dlant Villaga	05% total
	Detection of	for automatic ragion	Plaint Village	
	polato diseases	sagmontation	Dataset	accuracy
	segmentation	2 Feature extracted is		
	and multiclass	colour and texture		
	support vector	statistical analysis		
	machine	3 SVM were used as		
	inacinite	classifier		
[13]	Improved	1. Color negation and	Plant Village	99.25%
[]	Segmentation	conversion used for image	dataset	accuracy
	Approach for	enhancement.		
	Plant Disease	2. Colour thresholding and		
	Detection	morphological operation		
		for image segmentation.		
		3. Histogram and GLCM		
		used for feature extraction.		
		4. Used fully-connected		
		laver classifier.		

Table 1 Related work in Crop Disease Detection using Machine Learning Algorithm

Author	Title	Process	Result	Dataset
[14]	Deep Learning	1. Inception V3	SVM achieve	Cassava
	for image-based	CININ INOUGH IS	nighest accuracy.	Deteret
	Cassava Disease	tested with		Dataset
	Detection	varieties of		
[15]	Pagia	1 Imaga	The CNN	Cucumber
[15]	investigation on	1. Intage	The CININ	Lastimages
	a robust and	augmentation were	active average	Lear mages
	a robust and	deteset	82 2004	
	diagnostic	2 Two detects	82.30%.	
	system	2. I wo ualasets		
	system	trained their		
		custom CNN		
		models which one		
		have bad images		
		and other have		
		good images		
[16]	Unsupervised	1 In order to detect	The SVM	Plant Village
[10]	Convolutional	plant diseases	classifiers	dataset
	Autoencoder-	convolutional	outperform the	
	Based Feature	autoencoders is	fully-connected	
	Learning for	used for	networks.	
	Automatic	unsupervised		
	Detection of	feature learning		
	Plant Diseases	2. The output are		
		then feed to SVM		
		classifier.		
[17]	Plant disease and	1. Pretrained CNN	Resnet50 achieve	Images of
	pest detection	models are tested	highest accuracy	leaves and
	using deep	with different	of 97.86% but	pest from
	learning-based	classifier.	with SVM	Turkey.
	features	Classifier used are	classifier.	
		SVM, Extreme		
		Learning Machine		
[10]	Enn anima antal	(ELM) and KINN.	Coost Not sot	Diant Village
[18]	Experimental	1. 60 experimental	GoogLeNet get	Plant Village
	diagona detection	configurations	af 00.25%	Dataset
	based on doop	testing	01 77.33%	
	learning	2 AlexNet and		
	icarining	Googl eNet CNN		
		model were used		
		for testing		
	1	ioi usung.	1	

Table 2. Related work in Crop Disease Detection by using Convolution Neural Network

3. Experimental works and results

In this study, multiple general machine learning and convolutional neural network algorithm were evaluated to classify plant disease. All algorithm will be

trained and tested with same dataset which is part of public plant disease dataset named Plant Village Dataset [19]. For traditional based machine learning algorithm, the dataset will first be segmented with green pixel masking. Then, the feature will be extracted from the images. The feature extracted is Hu moments, Haralick and histogram. To classify the image several classifiers will be used which are Support Vector Machine, Logistic Regression, Linear Discriminant Analysis, K-Neighbours, Decision Tree, Random Forests and Gaussian Naïve Bayes.

Six CNN models are also evaluated in this experiment. The CNN models that are tested were VGG19, VGG16, Resnet50, Mobile net, InceptionResnetV2 and InceptionV3. All these models are fully connected layers with SoftMax at Dense layers. All models were train for 40 epochs with 16 batch size. The training will run on GPU to short the training time of the CNN models.

3.1. Dataset

Plant Village dataset is used in this experiment, which is an online image database which consist of variety images of crop diseases. In this experiment, the dataset used is tomato leaves images which the leaves infected by diseases. The 5 categories of images are Bacterial Spot, Early Blight, Late Blight, Leaf Mold and also healthy tomato leaves. 160 images were uses for training and 40 for testing for each class. The training images are split to 80:20 of train and test ratio.

Category	Original Dataset			
	Training Set	Testing Set		
Healthy	160	40		
Early Blight	160	40		
Late Blight	160	40		
Bacterial Spot	160	40		
Leaf Mold	160	40		

Table 3. Categories in plant diseases dataset

3.2. Results

This section provides the result of experiment done to compare the performance of CNN based algorithm and traditional machine learning algorithm. The precision, recall, accuracy and f1-score of models and classifier are tabulated in Table 4 and Table 5. Feature used for the classifier in Table 5 are Histogram, Hu moments and Haralick feature. Based on the result below, for CNN based algorithm InceptionResnetV2 gain the highest accuracy of 0.95 while for the traditional machine learning algorithm, Decision Tree classifier also got accuracy of 0.95. Mobile net accuracy is the lowest amount CNN based algorithm with 0.92 accuracy. The Gaussian Naïve-Bayes classifier achieve lowest accuracy of 0.73 accuracy.

Model	Precision	Recall	Accuracy	F1- Score
VGG19	0.89	0.89	0.89	0.89
VGG16	0.85	0.85	0.85	0.85
Resnet50	0.92	0.92	0.92	0.91
Mobile net	0.84	0.83	0.83	0.83
InceptionResnetV2	0.96	0.96	0.95	0.95
InceptionV3	0.94	0.93	0.94	0.94

	Table 4	Results	for	CNN	algorithm	experiment
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Classifier	Precision	Recall	Accuracy	F1- Score
Logistic	0.86	0.86	0.85	0.85
Regression				
Linear	0.85	0.85	0.85	0.85
Discriminant				
Analysis				
K-Neighbours	0.82	0.83	0.83	0.83
Classifier				
Decision Tree	0.81	0.81	0.81	0.81
Classifier				
Random Forest	0.96	0.96	0.95	0.95
Classifier				
Gaussian Naïve-	0.74	0.73	0.73	0.70
Bayes				
Support Vector	0.85	0.86	0.85	0.85
Machine				

Table 5 Result for traditional machine learning method

5. Conclusion

From the experiment result in Table 4 and Table 5, both traditional machine learning algorithms and CNN algorithms get very satisfying result. Random Forest Classifier and InceptionResnetv2 both gain 95% accuracy. Both algorithms have its own advantages. From the literature review, some research even gains higher accuracy of 99.35% by using CNN algorithm which also tested on Plant Village Dataset [18]. In the end, it all depend on research ability to fine tune the model or pick relevant features to extract. From this experiment, there were some advantages found on CNN based algorithms and traditional machine learning algorithm. CNN algorithm takes very long time to train compared to traditional machine learning algorithm even though the CNN algorithm were run on GPU to further speed up the training time. Traditional machine learning algorithm however depend heavily on green pixel masking, which is not very robust algorithm since green pixel value were put manually from the researcher. This make green pixel masking not effective on dataset which taken outside of the lab which have more vibrant colour of green.

For the future work, some further experiment can be done on CNN based algorithm. Right now, the models are fully connected model. The models can use which machine learning classifier for more variant result. For the traditional machine learning algorithm, the feature can be tested singularly instead of concatenated together to feed the classifier. There also other feature extraction method that are not tested yet such as GLCM and SIFTS.

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