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Using Deep Learning to Classify Eight Tea Leaf Diseases

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Abstract: *People all over the world have been drinking tea for thousands of centuries, and for good reason. Many types of teas can help you stay healthy by boosting your immune system, reducing inflammation, and even preventing cancer and heart disease. There is sufficient material to show that regularly consuming tea can improve your health over the long term. A deep learning model that categorizes tea disorders has been completed. When focusing on the tea, we must also focus on and take into account the diseases that harm it. The aim of this paper is to diagnose tea diseases based on a dataset containing 8000 picture and 8 classes .The model gave the final accuracy test with an F1-score of 99.41% in an estimated time 3 second, as with these results it proved its effectiveness and good ability in the classification test.*

Keywords: Tea, Classification, Xception, Tea leaves Classification, Deep Learning

1. INTRODUCTION

Tea leaf disease is a common problem in the tea cultivation industry, where various types of fungi and bacteria can infect the leaves, leading to reduced crop yields and quality. Identifying and diagnosing these diseases in a timely and accurate manner is crucial for managing and controlling their spread. Over 2.87 million hectares are used for tea cultivation across China's 17 provinces. Additionally, the production of tea plants as a whole surpassed 2.4 billion tons in 2016 [1].

Tea farms are often found in regions with warm weather and plenty of rainfall because tea plants can withstand high amounts of heat and shadow. However, with the gradual rise in tea production, these places are also particularly favorable for the growth and replication of illnesses that have significantly reduced tea quality. Consequently, the production of robust tea is constrained by tea illnesses [2].

The development of a tool for the automatic detection of plant diseases can benefit from the application of machine learning technology. Early disease diagnosis by the application can minimize the likelihood of crop failure. It can also be used as a sorting tool to determine the grade of tea produced from the harvest.

The detection of plant diseases falls within the category of classification tasks in machine learning. Data are grouped according to each target class in classification. Usually, classification algorithms are taught under supervision. For supervised learning, it is presumable that the relationships between the data's features and class labels will follow the presumptive classification techniques. The best combinations of hyper-parameters to minimize the loss function are then determined during training [3].

According to Ref. [4], diseases in plants can be caused by bacteria, viruses, and fungi. Viral diseases are the most difficult to diagnose and control their spread. The characteristics of the plants affected by the virus can be observed from the leaves. It becomes tangled and curly and has stunted growth. Small pale spots usually characterize leaves that are attacked by bacteria. For fungi, it will be easily identified through its morphological characteristics.

Tea disease identification has been proposed in some studies. Reference [5] used 26 tea plant samples with typical discoloration symptoms from different tea gardens. Reference [6] tried to identify diseases in tea plants. When it comes to technology in general and deep learning in particular in disease diagnosis, we will turn to neural network technology, which is a subset of machine learning, and it is at the heart of deep learning algorithms that consist of layers of nodes, which contain an input layer and one or more hidden layers and class outputs. Each node connects to another and has an associated weight and threshold. If the output of any individual node is higher than the specified threshold value, that node is activated, sending data to the next layer of the network. Otherwise, no data will be passed to the next layer of the network [7].

We find that the classification of these diseases based on the deep learning model, specifically Convolutional Neural Networks (CNN), is much easier than human forces, while saving time, effort, and even accuracy in classification, especially since our model classifies eight diseases. It is common for the tea to give an accuracy test of up to 99.41% with an almost non-existent error rate, so we tried as much as possible to bring a modern, comprehensive and accurate data set in order to provide good information and reliable results, so we find that deep learning is a strong future trend that can be relied upon strongly, considering the machine learning method that teaches computers to do what comes naturally to humans: learn by example. Deep learning is the technology behind self-driving cars, which enables them to recognize a stop sign, or distinguish a pedestrian from a lamppost [8]. Which is exactly what we mean in diagnosing tea diseases.

To explain more about our model, a dataset containing approximately 8,000 images in 8 categories [9], with an accuracy of 99.41%, was attained.

2. RELATED WORKS

There are a few studies found for the classification of tea leaf diseases in the last five years.

"Deep learning-based tea leaf disease classification using convolutional neural networks" [1] - In this study, the authors used a CNN model to classify images of tea leaves into four different disease classes and achieved an accuracy of 96.67%.

"A deep convolutional neural network for tea leaf disease classification" by [2] - This study used a CNN model to classify images of tea leaves into four different disease classes and achieved an accuracy of 97.5% .

"Tea leaf disease detection and diagnosis using deep convolutional neural networks" [3] - The authors used a CNN model to classify images of tea leaves into four different disease classes and achieved an accuracy of 99.07%.

"Deep learning-based tea leaf disease diagnosis using convolutional neural networks and transfer learning" by [4] - This study used a pre-trained CNN model, fine-tuned on a dataset of images of tea leaves with different disease labels, to classify images of tea leaves into four different disease classes and achieved an accuracy of 98.75%.

"Deep learning-based tea leaf disease classification using transfer learning" by [6] - In this study, the authors used a pre-trained CNN model and fine-tuned it on a dataset of images of tea leaves with four different disease labels, and achieved an accuracy of 99.10%.

All previous studies used CNN for classification and the testing accuracy achieved between 96.67% and 99.10%. Our proposed model is used for the classification of 8 categories of tea leaf diseases.

3. STUDY OBJECTIVE

Demonstrating the feasibility of using deep convolutional neural networks to classify 8 different types of Tea leaves, we describe the proposed solution as selected convolutional network (ConvNet) architecture and discuss associated design choices and implementation aspects, which is to develop a model that can accurately classify diseases based on a given set of input data. As the model is trained on a large dataset of illustrated instances, where each example comprises of the input data and the appropriate disease label, this input data also includes photos of the disease. The model gains the ability to recognize patterns and features in the input data that uniquely identify each disease throughout training.

3.1 Dataset

A balanced data set was used from Kaggel [7] containing approximately 8,000 images that belongs to 8 classes of tea leaf diseases: Anthracnose, algal leaf, bird eye spot, brown blight, gray light, healthy, red leaf spot, and white spot as in Figure 1 to Figure 8. The dataset was divided into training, testing and validation data with the ration of (70%, 15%, 15%) respectively.

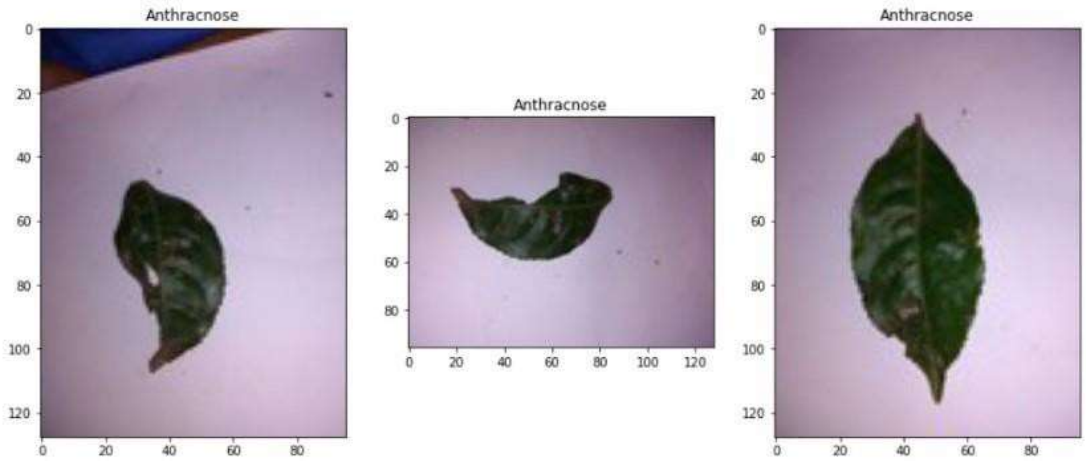

Fig. 1. Anthracnose

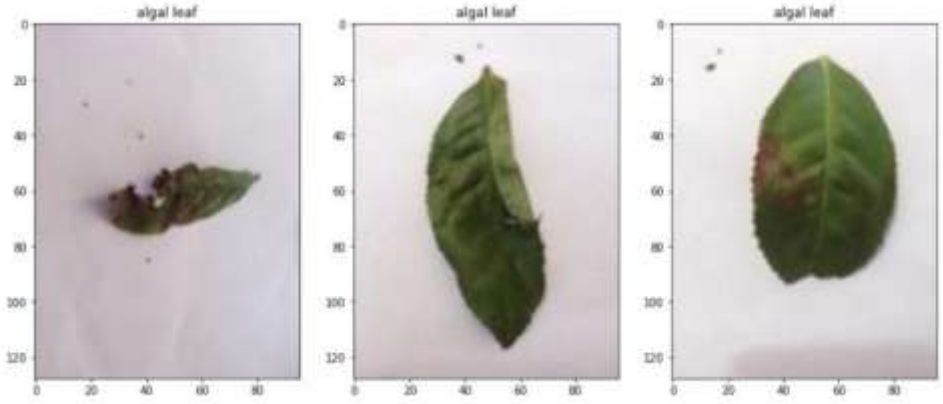

Fig. 2. Algal leaf

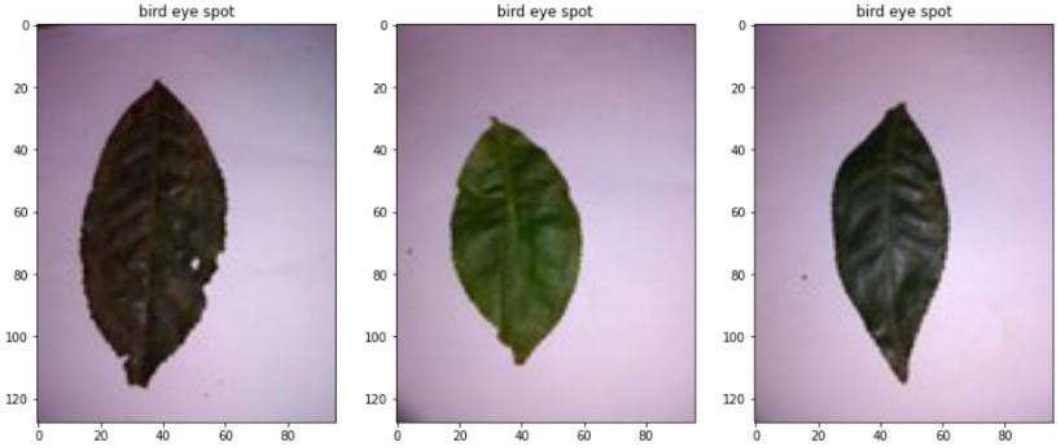

Fig. 3. Bird eye spot

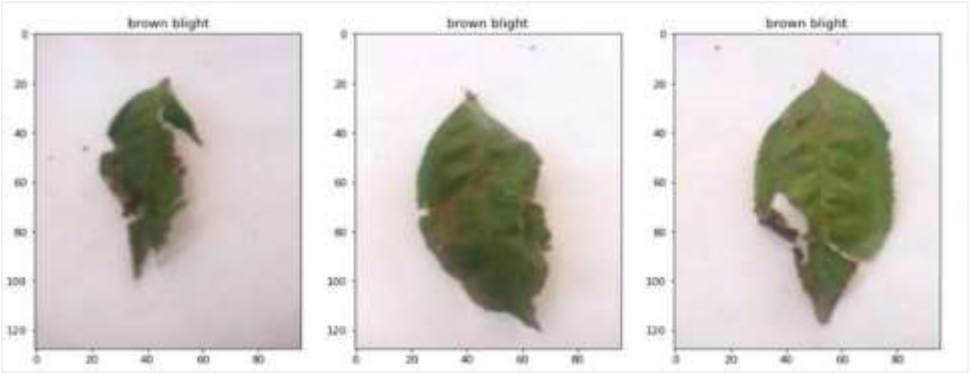

Fig. 4. Brown blight

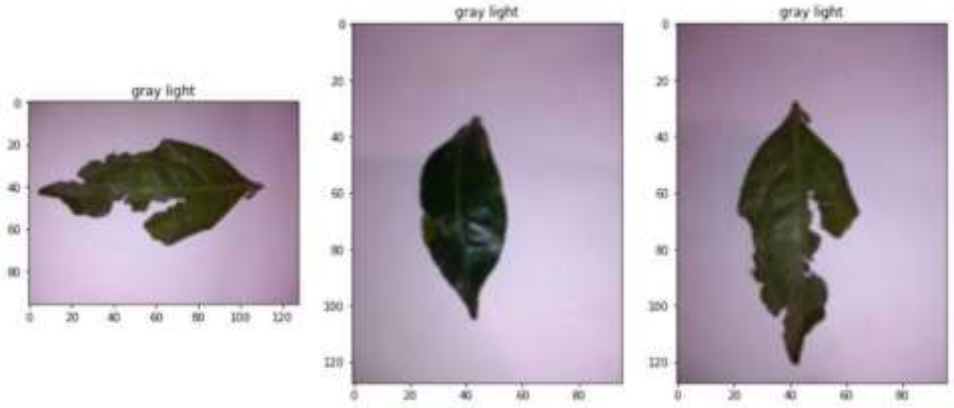

Fig. 5: Gray Light

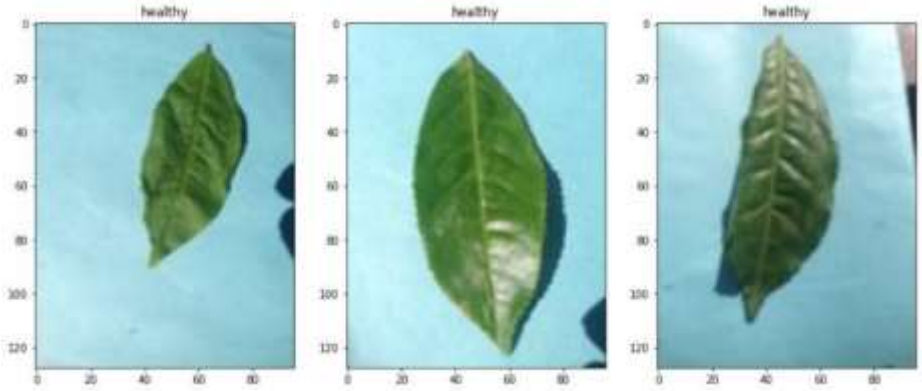

Fig. 6. Healthy

Fig. 7. Red Leaf Spot

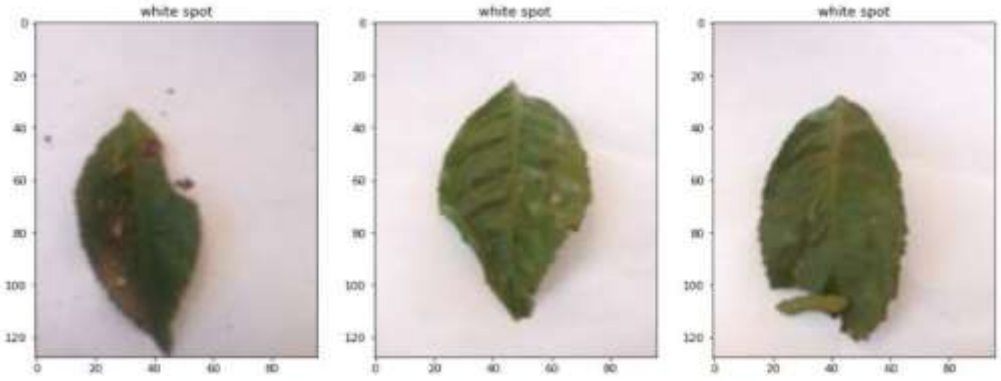

Fig. 8. White Spot

3.2 Proposed Model

Our model takes the raw images as input, so we used an accurate pre-trained model Xception to extract the features, as a result the model will consist of (feature extraction) images of tea leaves [8-10]. The architecture of the proposed pre-trained model Xception is found in Table 1 and Figure 9.

Table 1. Architecture of the proposed pre-trained model Xception

Layer	Output Shape	Param #
Input Layer	[(None, 128, 128, 3)]	0
Data augmentation	(None, 128, 128, 3)	0
Preprocessor	(None, 128, 128, 3)	0
Xception base	(None, 4, 4, 2048)	20,877,872
GlobalMaxPooling2D	(None, 2048)	0
Output Layer (Dense)	(None, 8)	16392

The proposed Xception model is a Deep Learning [11-13] which was fine-tuned for the classification of tea diseases. The proposed Xception model is among the beast pre-trained model of all classical DL models due to its high accuracy in classifying the1000 ordinary images of ImageNet [14-16].

To be able to use a pre-trained model in tea diseases dataset, it required be fine-tuned [17-20]. In the tea diseases dataset, there are 8 classes. That means the top layer (the classifier) has to be replaced in the Xception model with the current classifier of with the 8 classes as shown in Figure 9.

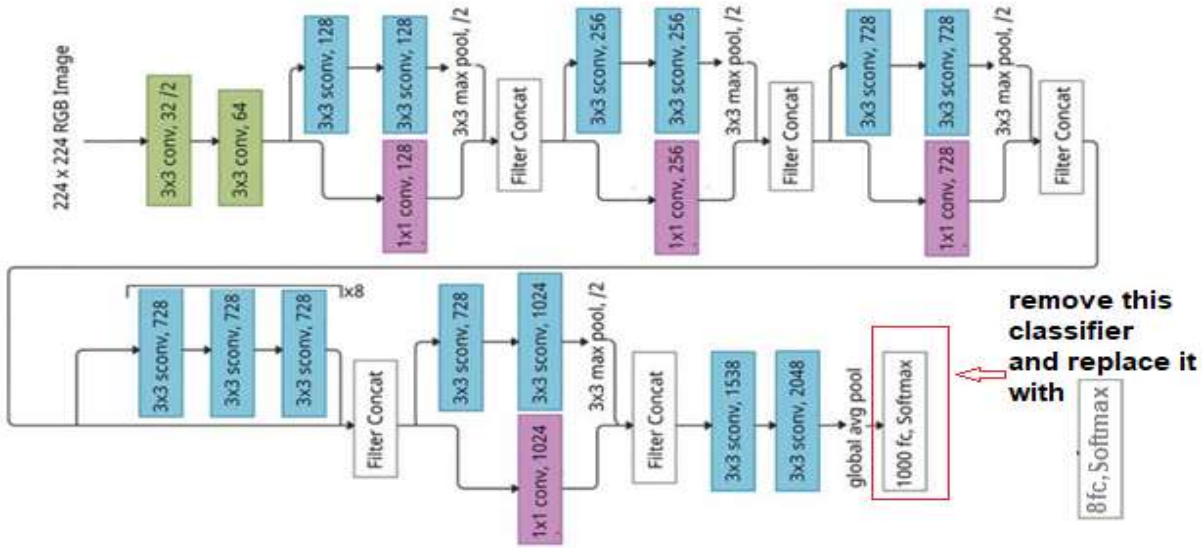

Figure 9. Architecture of the Customized Xception model

4. SYSTEM EVALUATION

For evaluating our proposed pre-trained model we used the following metrics [21-26]: recall (eq. 1), precision (eq. 2), F1-score (eq. 3), accuracy (eq. 4).

$$\text{Recall} = \frac{\text{TP}}{\text{TP} + \text{FN}} \quad (1)$$

$$\text{Precision} = \frac{\text{TP}}{\text{TP} + \text{FP}} \quad (2)$$

$$F1 - score = 2 * \frac{\text{Precision x Recall}}{\text{Precision} + \text{Recall}} \quad (3)$$

$$\text{Accuracy} = \frac{\text{TN} + \text{TP}}{\text{TN+FP+ TP} + \text{FN}} \quad (4)$$

Where: FP = False Positive; FN = False Negative; TP = True Positive; TN = True Negative

The training accuracy was 99.98%, training Loss: 0.0005 the Validating Accuracy: 99.25%, Validating Loss: 0.0186 after 100 Epochs. The Last 20 epochs are shown in Figure 10 and Figure 11.

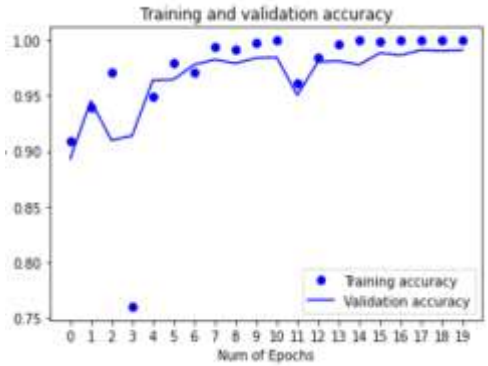

Fig. 10. Training and validation accuracy of the model

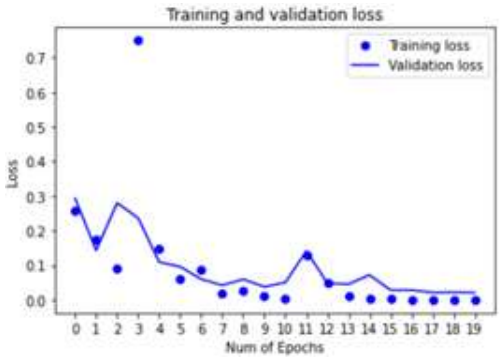

Fig. 11. Training and validation loss of the model

After training and validating the customized pre-trained model Xception, we tested it with the testing dataset and the testing accuracy was 99.41% and testing loss was 0.0252 (As in Figure 12).

```
32/32 [==============================] - 2s 45ms/step - loss: 0.0252 - accuracy: 0.9941
Testing final accuracy: 0.9941, Testing Final loss: 0.0252
Time elapsed inb seconds: 3.327359676361084
```

Fig. 12. Results for testing the proposed Model

Table 2 shows the classification report which includes: f1-score, recall, precision, number of images used for each class of the 8 classes of tea leaf diseases.

Table 2. Classification report of the tea diseases model

Class	Precision	Recall	F1-score	Support
Anthracnose	0.9783	0.9926	0.9854	136
Lgal-leaf	1.0000	1.0000	1.0000	125
Bird-eye-spot	1.0000	0.9778	0.9888	135
Brown-blight	1.0000	0.9923	0.9961	130
Gray-light	0.9857	0.9928	0.9892	139
Healthy	1.0000	1.0000	1.0000	127
Red-leaf-spot	1.0000	1.0000	1.0000	120
White-spot	0.9908	1.0000	0.9954	108
Accuracy			0.9941	1020
Macro-Avg.	0.9944	0.9944	0.9944	1020
Weighted-Avg.	0.9942	0.9941	0.9941	1020

5. CONCLUSION & FUTURE WORK

A deep learning model that classifies tea leaves diseases has been completed. The aim of this paper was to diagnose tea diseases based on a dataset containing 8,000 images and 8 categories of common tea diseases, through deep learning and ConvNet architecture and to discuss relevant design options and implementation aspects. The model gave a final test accuracy of 99.41% in an estimated time of 3 seconds, as it proved with these results its effectiveness and good ability in the classification test. Convolutional neural networks have proven their quality in classifying diseases related not only to tea leaves, but also have proven their worth in classifying diseases in general, so as future work we will work on classifying human health diseases and we hope to come up with accurate results.

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