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Smartphone Application for Deep Learning-Based Rice Plant Disease Detection

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***Abstract*—An increase in the human population requires an increase in agricultural production. Generally, the most important thing in agriculture that affects the quantity and quality of crops is plant diseases. In general, a farmer knows that his plant is attacked by a disease through direct vision. However, this process is sometimes inaccurate. With the development of machine learning technology, plant disease detection can be done automatically using deep learning. In this study, we report on a deep learning-based rice disease detection system that we have developed, which consists of a machine learning application on a cloud server and an application on a smartphone. The smartphone application functions to capture images of rice plant leaves, send them to the application on the cloud server, and receive classification results in the form of information on the types of plant diseases. The results showed that the smartphone-based rice plant disease detection application functioned well, which was able to detect diseases in rice plants. The performance of the rice plant disease detection system with VGG16 architecture has a train accuracy value of 100% and a test accuracy value of 60%. The test accuracy value can be improved by adding the number of datasets and increasing the quality of the dataset. It is hoped that with this system, rice plant disease control can be carried out appropriately so that yields will be maximized.**

Keywords— rice plant, disease detection, a smartphone application.

I. Introduction

The most important thing in agriculture that affects the quantity and quality of the crop is plant diseases [1]–[6]. Rice is the staple food in Indonesia. The rice crop faces serious problems due to diseases resulting in reduced yields. Usually, to overcome disease problems in rice plants, farmers routinely spray pesticides on plants to eradicate pests, both plants, insects, and other animals. However, pesticide spraying on plants is often done not based on accurate information about the health conditions and diseases of the plants. If the pesticide spraying is excessive, it will pollute the environment and be harmful to the health of humans who consume the plants [7], [8]. Every disease has a different remedy to treat [9]. Not all pests and diseases must be controlled by spraying pesticides because there are pests that can be controlled by placing light traps or just being flooded. On the other hand, pesticide sprays will not be successful in controlling the population of a pest if it is not in the right phase. Pesticides should be used as a final step which is applied correctly on target, on the type, on time, and in the right dose so as not to cause greater losses. An understanding of the appearance, symptoms of attack, the character of plant pests, and the life cycle is the key to successful control [10].

In addition, increasing the human population requires increased foodstuffs [11], [12], in this case technology is very important in sustainable agriculture to increase agricultural yields. Today's technological breakthroughs ensure that the development and discovery of new technologies is a continuous effort that makes sustainable agriculture possible. Agricultural technology innovation is the basis for meeting the new demand for food [13]. Usually a farmer knows that his crop is attacked by a disease through direct observation in the field. However, this habit is time-consuming and laborious on large plantations and is sometimes less accurate [14]. In addition, these methods are limited to cognitive phenomena and psychological that can lead to errors and illusions [15].

II. Related Works

Recently, deep learning technology has been popularly used in various sectors, especially in agriculture [16][7]. The deep learning method has several advantages over other machine learning methods. First, this method is using a neural network that can be used to take advantage of interactions and feature hierarchies. Second, processes such as selection, classification, and feature extraction can be recognized through deep architectural optimization processes. Currently, the most common and widely used architecture in deep learning is a convolutional neural network (CNN) [15][17]. CNN is widely used in the fields of face recognition, image classification, object detection, etc. The CNN model consists of components of activation functions, fully connected layers, pooling layers, convolutional layers, etc [18], [19]. With the development of machine learning technology, plant disease detection can be done automatically using CNN through a deep learning methodology [20], [21].

Several studies regarding the use of machine learning to detect diseases in rice have been carried out. Ramesh et al used a machine-learning algorithm such as an artificial neural network (ANN) to find symptoms of rice blast disease in rice plants [1]. Lu et al used a deep learning algorithm, namely CNN, to identify 10 common types of rice diseases [21]. Burhan et al. have compared the performance of Deep Learning from five different models, namely ResNet50, ResNet50V2, ResNet101V2, VGG16, and VGG19 on both artificial data and images collected from fields. The artificial dataset has been arranged according to groups into four classes of hispa, leaf blast, brown spot, and healthy [22]. However, previous studies have not discussed the development of smartphone applications as plant disease detection devices on the client side and deep learning applications on the server side.

In this research, we have developed a smartphone application for detection of rice plant disease based on deep learning. It is hoped that with this smartphone application, disease control can be carried out appropriately so that the harvest will be optimal [23].

II. Research Method

The research method for developing a smartphone application for detection of rice plant disease based on deep learning consists of four steps, namely designing plant disease detection system architecture, developing application on cloud server and smartphone applications, testing smartphone applications, and evaluating the performance of a plant disease detection system. Fig. 1 shows the research methodology used in this study.

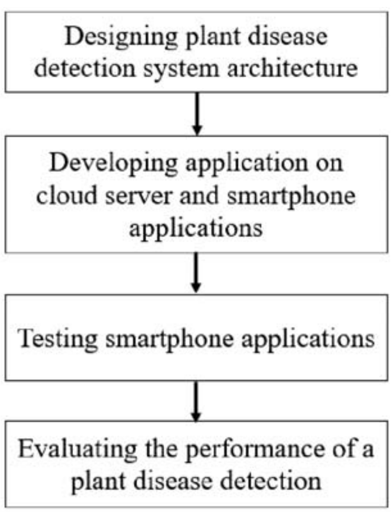

Fig. 1 The research methodology

A. The Rice Disease Detection System Architecture

Fig. 2 shows the rice disease detection system architecture consists of images of rice plant leaves, machine learning models on the cloud server, and plant disease detection applications on smartphones. The training result model in the cloud server is used to process images of rice plant leaves into rice plant disease information. The rice plant disease detection application on a smartphone will take pictures of rice plant leaves through the camera on the smartphone, then send the image to the platform on the cloud server. The platform will process rice plant leaf images and send the results of the classification of rice plant disease types to the smartphone application. The smartphone application will receive the information and display it.

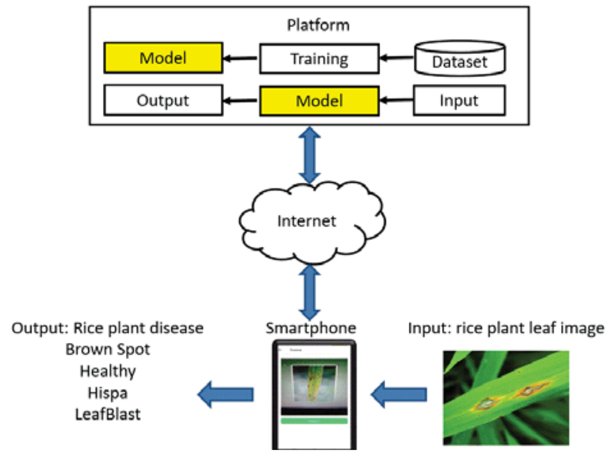

Fig. 2 The architecture of smartphone application for detecting rice plant disease

B. Application on Cloud Server and Smartphone

Application to detect diseases in rice plants are divided into two, namely cloud server application and smartphone application. The cloud server application is made using the Python programming language with Flask as a Web Framework which is useful for running plant disease identification models. Meanwhile, the smartphone application is built using the React Native Cross-Platform Mobile Application. The smartphone application is used as a tool to get crop image input using the camera which will be sent to the cloud server application in the form of a REST API. Then the cloud server application performs plant disease predictions on the input image and sends the results to the smartphone application.

We took the dataset of rice plant disease from Kaggle with the number of images 1600. Disease detection in rice plants using image processing and deep learning. Fig. 3 shows the process of creating the model and identifying rice plant diseases. The disease detection process in rice plants consists of a training process to get a model and a testing process to determine the type of disease in rice plants based on the model.

The training process uses images taken from the dataset. Image pre-processing involves taking the extracted infected part from a leaf image. Pre-processing of image is used to remove things that are considered noise that can cause problems at the segmentation and feature extraction stage. In addition, in this stage, image size reduction is also carried out. Image segmentation is dividing the image into specific objects or areas. The main objective of image segmentation is that the system can extract useful features from the image through the image data analysis process. The model is made on CNN, where features are extracted from an already segmented image. The feature extraction part of image analysis is centered on recognizing the features of an object in an image. This feature can be used to describe objects. Typically, features grouped into the following three categories are extracted: texture, color and shape. Texture means how the color patterns are spread out in an image. Some of the features of shape are axis, angle, and area. Color is one of the important features, because color can distinguish one disease from another disease in plants. Furthermore, each disease may take a different form; so that the system can distinguish diseases using form features. Backpropagation training is also carried out on CNN to minimize errors. Classification aims to map data into certain classes or groups. In the classification of plant diseases, the diseases were grouped based on the features extracted [9].

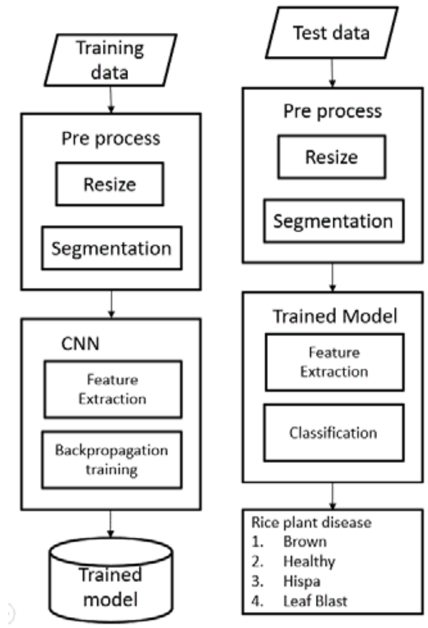

Fig. 3 Identifying rice plant diseases process

We are using the deep learning model VGG16 for classifying plant disease. VGG16 is a CNN architecture which has 16 weight layers [15]. Fig. 4 shows VGG16 model. The CNN network consists of two parts, namely, a classifier half and a convolutional half. At the convolutional half, the image features are defined by a group of layers. The layers in the convolutional half are the activation layers, the batch normalization layers, the convolutional layers, and pooling layers. At the classifier half, dense layers and dropout layers classify images based on the resulting features of the convolutional half.

The steps of the data testing process are as follows, the image of rice plant leaves is derived from test data, then the test data image is processed, the infected part is extracted, then the features are extracted. The last step, the classification of the disease is carried out using a model. We divide rice plants into healthy rice plants and unhealthy rice plants. Unhealthy rice plants are plants that are affected by the disease. Fig. 5, Fig. 6, and Fig. 7 shows the types of rice plant diseases consist of Brown, Leaf Blast, and Hispa. Fig. 8 shows a healthy rice plant.

Brown Spot is one of fungal disease that strike panicles, leaf sheath, coleoptile, and glume. Seeds infected with this disease can affect future crops. Although brown spot can attack at all phases of growth, rice plants are highly susceptive to ripening and tillering. They appear as small yellow-brown lesions on the leaves and may develop into red patches with a gray or light brown core [22].

Likewise, Leaf Blast is another fungal disease that attacks all parts of rice plants such as the neck, internodes, panicles, and leaf sheaths. Leaft Blast can be found at all phases of growth. It appears as a greenish-gray spot or whitish which then develops a reddish-brown center and a necrotic border [22].

On the other hand, Hispa is not a disease caused by fungi but rather crop damage caused by pests. The mature hispa is a bumblebee about 5mm long. Hispa eats the leaves by scraping the surface of the leaves so that white lines show on the leaf superficies. The female hispa places the eggs in this scraping so that this pest population continues to go up rapidly. If it is not detected on time, the delay in controlling this disease by using pesticides will result in damaged rice fields within three weeks. [22].

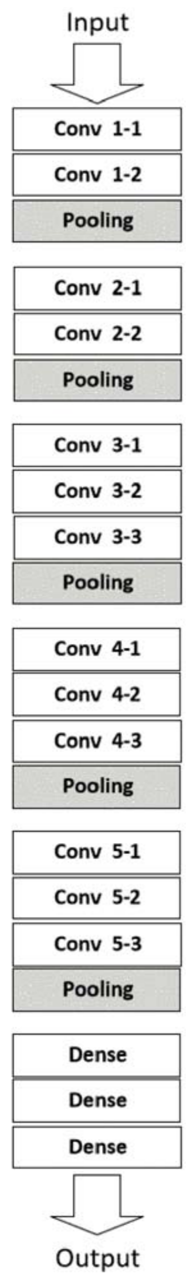

Fig. 4 VGG16

Fig. 5 Brown

Fig. 6 Leaf Blast

Fig. 7 Hispa

Fig. 8 Healthy

III. RESULTS AND DISCUSSIONS

Smartphone application testing is done by running a smartphone application to detect diseases in plants, take an image of rice plant leaves and seeing the results of disease detection on the smartphone screen. Fig. 9 shows smartphone application to detect rice plant diseases. From the test results, it shows that the application on the smartphone is functioning properly, which can detect diseases in rice plants.

The performance evaluation of the machine learning algorithm is done by measuring the accuracy, precision, F1-score, recall, and a confusion matrix. Accuracy is the ratio of the total of correct predictions to the amount of predictions, accuracy is usually presented as a percentage and calculated using [15]:

$$Accuracy = \frac{Total\ correct\ prediction}{Total\ prediction} \quad (1)$$

Precision is used to determine a model's ability to precisely predict values for a specific category, precision is calculated using [15]:

$$Precision = \frac{Certain\ category\ predicted\ correctly}{All\ category\ predictions} \quad (2)$$

Recall is used to measure positive pattern fractions that are classified correctly, recall is calculated using [15]:

$$Recall = \frac{Correctly\ Predicted\ Categories}{All\ Real\ Categories} \quad (3)$$

The F1-score is an average value of recall and precision [15]. A confusion matrix is a matrix that is usually used to show the classification model performance on a test set whose correct values are identified by mapping the predicted output across the actual output. Confusion matrix to describe graphical displays, which is the usual way to analyze classification results using test dataset.

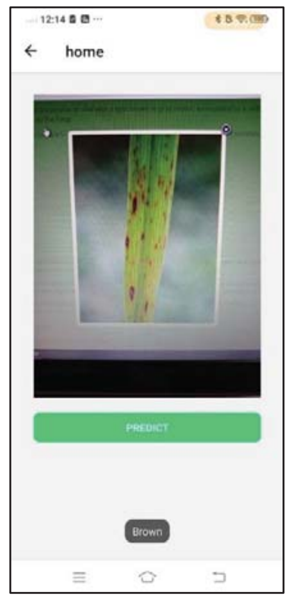

Fig. 9 Smartphone application to detect rice plant diseases

The dataset consists of 1600 images in which 80% of the dataset is for training data, and 20% of the dataset is for testing data. Data pre-processing resizes the data dimensions to 200 x 200 pixels. Then the data will be segmented using the Canny Edge method. The training was carried out with 100 epochs with a learning rate parameter of 0.0001. The optimization used in this study is Adaptive Moment Estimation (Adam). Fig. 10 shows model accuracy and model losses with Adam's Optimizer at a learning rate of 0.0001. At epoch 38 there was a very rapid increase in losses. While the accuracy of the test data still fluctuates until the last epoch. The result of a train accuracy value of 100% and a test accuracy of 320 images is 60%. Table I shows the performance evaluation of the machine learning algorithm.

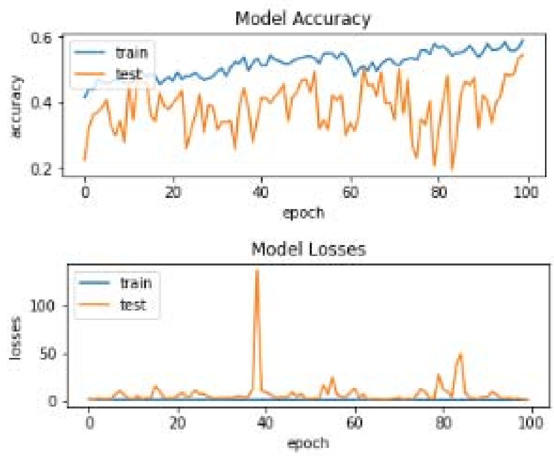

Fig. 10 Model accuracy and model losses

TABLE I. THE PERFORMANCE EVALUATION OF THE MACHINE LEARNING ALGORITHM

Rice plant diseases	Performance evaluation			
	precision	***recall***	***F1-score***	***support***
Brown Spot	0.78	0.70	0.74	74
Healty	0.45	0.49	0.47	71
Hispa	0.58	0.62	0.60	92
Leafblast	0.61	0.57	0.59	83
Accuracy			0.60	320
Macro avg	0.60	0.60	0.60	320
Weighted avg	0.60	0.60	0.60	320

Fig. 11 shows a confusion matrix. The Hispa class has the most accurate compared to other classes and has the most amount of data from the results of the test data distribution.

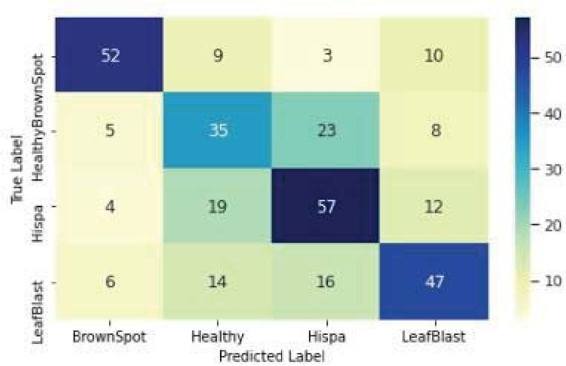

Fig.11 Confusion Matrix

CONCLUSION AND FUTURE WORK

We have successfully developed a smartphone-based rice plant disease detection application. The results showed that the smartphone-based rice plant disease detection application functioned well, which was able to detect types of rice plant diseases build upon image processing of rice plant leaves using VGG16 with a train accuracy value of 100% and a test accuracy value of 60%. Hispa class has the most accurate compared to other classes because it has the most amount of data from the results of the test data distribution. In our future work, we will increase a test accuracy value by using more datasets and cleaning datasets from noise. Also, we will develop this application with various functions, for example, the function to provide recommendations on how to treat diseases in plants.

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