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Classification of Monocot and Dicot Plants Using Convolutional Neural Network

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Abstract—*This research aims to differentiate monocot and dicot leaf bones using Convolutional Neural Network (CNN) method. To identify the types of dicot and monocot plants, a classification system utilizing deep learning algorithms can be created. The data used in this study consists of images of 2 dicot plants and monocot plants obtained by manually downloading them from the image search column on Google's website. The total data obtained from the download process in this study amounts to 1000 images in *.jpg format with various resolutions. By applying the Convolutional Neural Networks (CNN) algorithm to the research objects, dicot and monocot plants can be detected based on the model created, with a testing result accuracy of 0.93%. Furthermore, it is expected that this research can assist those in need of information for further studies, particularly in distinguishing between dicot and monocot plant species.*

Keywords— *Classification, Plants, Monocot, Dicot, CNN.*

I. INTRODUCTION

Image processing using artificial intelligence techniques, such as machine learning and artificial neural networks, has been utilized in various agricultural studies (Souza et al., 2019). Image processing is a system where the process is carried out with input in the form of images and the output is also in the form of images or information from an image (Mulyawan et al., 2011). Machine learning, a branch of artificial intelligence and computer science, focuses on using data and algorithms to mimic human learning and gradually improve its accuracy (IBM, 2020). It is an essential component of data science, where through the use of statistics, machine learning algorithms are trained to make classifications or predictions in data development. One task in machine learning is supervised learning, which includes regression and classification.

Research conducted by Tsabitah Ayu, Vizza Dwi, and Agus Eko Minarn in 2021 utilized a model built with the Convolutional Neural Network (CNN) algorithm to help farmers distinguish between pest-infested leaves and healthy leaves. The dataset, in the form of .JPG images, consisted of 435 images of 32 types of mangoes. The research achieved a fairly accurate accuracy of 96% in predicting pest-infested mango leaves compared to healthy ones.

Classification itself includes various models, including geometric models, rule-based models, probabilistic models, hybrid models, and neural network models. An example of a neural network model is deep learning, a subfield of machine learning whose algorithms are inspired by the structure of the human brain. This structure is called Artificial Neural Networks (ANN), which fundamentally consists of three or more layers (IBM, 2020).

One method applicable to deep learning is the classification method using the Convolutional Neural Network (CNN) algorithm. CNN is a type of neural network commonly used for image data. CNN is an extension of the Multilayer Perceptron (MLP) for processing two-dimensional data. CNN falls under the category of Deep Learning due to its high network depth and frequent application to image data (Yuliani et al., 2019). Related research on deep learning implementation states that CNN has multiple layers that extract information from images and determine image classifications in the form of classification scores. Therefore, deep learning has become a hot topic in the world of machine learning due to its significant capability in modeling various complex data (Nugroho et al., 2020). Some CNN architecture models available in Keras include Xception, VGG16, InceptionResNetV2, MobileNetV2, NasNetMobile, and many more (Keras, 2022).

This research aims to implement the Convolutional Neural Network method for classifying dicot and monocot plants and determining the resulting accuracy level).

II. METHODS

The framework provides a step-by-step overview of the initial data analysis process to drawing conclusions from the analyzed data. The framework is organized as shown in Figure 1:

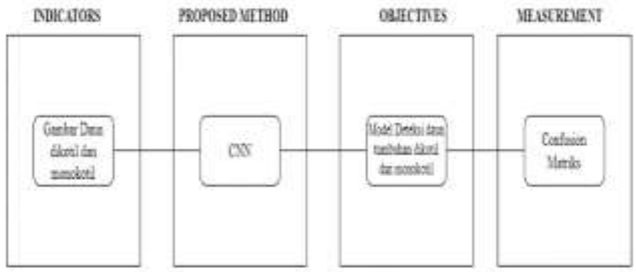

Fig. 1. Framework Methods

1. *Indicators*

Indicators are parameters tested in a study, defined with inputs to be processed in subsequent stages. In this research, indicators are images of monocot and dicot plant leaves, which will be processed in the next stage.

2. *Proposed Method*

The Proposed Method includes the method determined as a problem-solving solution based on the previously obtained indicators. In this study, the author uses the classification

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method in deep learning with the CNN algorithm as the proposed method to analyze the mentioned indicators.

3. Objectives

Objectives represent a goal or target to be achieved in a study. The goal of this research is to obtain the best Convolutional Neural Network (CNN) algorithm model from the conducted modeling.

4. Measurement

Measurement is the process of assessing the results of a study. After going through the stages of data collection, preprocessing design, CNN design, and creating a detection system model, a validation test is needed for the analyzed method. Testing is done using a Confusion Matrix to measure accuracy, precision, recall, and F1 score as indicators of the accuracy of the formed model.

Research Stages

In the stages of dicot and monocot classification research using the CNN algorithm method, the process is illustrated in the following figure 2:

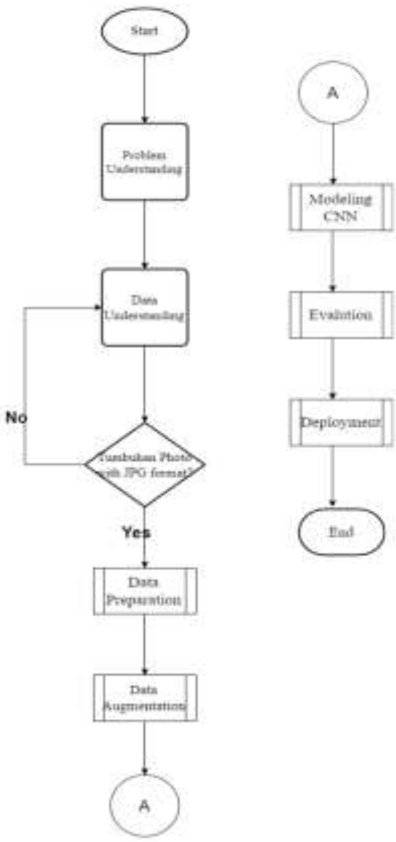

Fig. 2. Research Stage Figure

The first stage is problem understanding, followed by data understanding, data preparation, data augmentation, modeling, evaluation, and deployment.

III. Result And Discussion

The author collected data in the form of .jpg image files, amounting to 1000 images. This image dataset consists of dicot and monocot leaf images. The dataset is divided into three subsets: Training, Validation, and Test, with a total of 1000 data points. The subsets must not overlap as it would disrupt the model training process; therefore, the training size is much larger than the validation and test data. Too small training data will hinder model learning. The function of the training data is to train the model, the validation data is for the training process, producing a loss function to consider whether the data is overfitting or underfitting, and the testing data is used to test the model as a simulation of model use in the real world.

CNN Model Formation Results with Xception model addition

In this stage, data is processed using the classification method with the Convolutional Neural Network (CNN) algorithm, employing different architectures in each experiment, as shown in Figure 3:

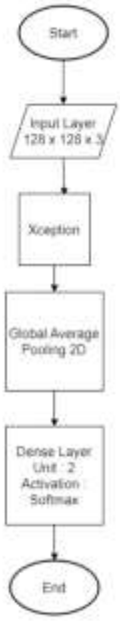

Fig. 3. Flowchart Process Training Model – CNN Add Model Xception Figure

With input dimensions of 128x128x3, the architecture is formed with a total of three layers. The modeling is performed using the Xception architecture first, followed by the Pre-trained Base Model layer (base_model), Global Average Pooling 2D layer (tf.keras.layers.GlobalAveragePooling2D()), and the Dense layer. The architecture in the figure above is created with the following hyperparameters, and trial and error in hyperparameter values help find the architecture with the best accuracy.

TABLE I. Hyperparameter Experiment A – CNN Add Model Xception

Hyperparameter	
Split data	80% Train, 10% Valid, 10% Test
Batch size	200
Layers	3
Epoch	5
Optimizer	Adam
Learning rate	0.001

In the table 1, data is divided into 80% Train, 10% Valid, and 10% Test, using a batch size or sample data distributed to the Neural Network as 200. This means that with 1000 datasets, the CNN algorithm will use the first 200 data samples from the 1000 data it has, then distribute or train them through the Neural Network until finished, then take the next 200 samples from the 1000 data, and so on. The layers being 3 means that the architecture consists of 3 layers: Pre-trained Base Model layer (base_model), Global Average Pooling 2D layer (tf.keras.layers.GlobalAveragePooling2D()), and Dense layer. Epoch 5 means the training process is carried out five times. Next is the use of the Adam Optimizer to iteratively update weights based on training data, and the last 200 use a learning rate of 0.001, where the smaller the learning rate, the more detailed the model will learn the training data.

Model Training

After all model architectures are ready, the next stage is to train the data. In this process, model fitting is performed to obtain a model that will be used for testing. The hyperparameters determined in the previous stage are used to determine the accuracy value. The following are the results of the model training process for each experiment.

TABLE III Training model Experiment A – CNN Add Model Xception

No	Epoch	Loss		Accuracy	
		Loss	Val_Loss	Accuracy	Val_Accuracy
1	1	0.6445	0.0179	0.6550	0.8100
2	2	0.4197	0.4141	0.8475	0.9300
3	3	0.3121	0.3540	0.8925	0.9700
4	4	0.2268	0.3194	0.9613	0.9300
5	5	0.1839	0.2919	0.9787	0.9300
Total Trainin accuracy = 0,93 %					

The values in the table will produce a graph like the one show as figure 4:

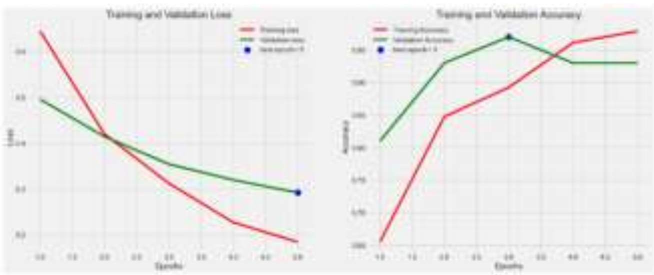

Fig. 4. Training Process Result Experiment A – CNN Add Model Xception Figure

The figure shows that the model slowly and in detail learns the training data, as seen in the gradually decreasing curve for training and validation loss, measuring how well the learning model performs in predicting the target. For training and validation accuracy, the curves gradually rise, indicating an increase in accuracy performance.

Model Testing

To ensure the model needs retraining or not, model testing can be performed using a confusion matrix, where the output of this test is accuracy, precision, recall, and F1 results. The results of model testing for each experiment are as show figure 5:

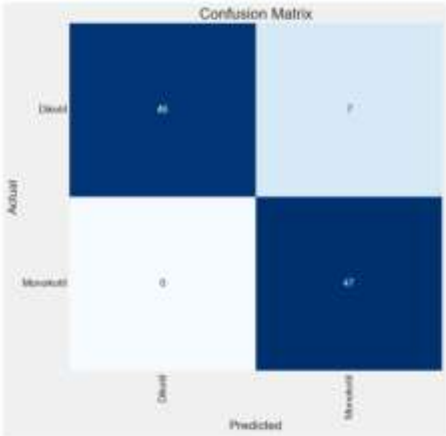

Fig. 5. Model Testing Result Experiment A – CNN Add Model Xception

The results show as Figure 6:

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Classification Report:
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              precision    recall  f1-score   support

     Dikotil       1.00      0.87      0.93        53
   Monokotil       0.87      1.00      0.93        47

    accuracy                           0.93       100
   macro avg       0.94      0.93      0.93       100
weighted avg       0.94      0.93      0.93       100
```

Fig. 6. Classification Report

The figure show True Positive (TP) as 53 images, True Negative (TN) as 47 images, False Positive (FP) as 0 images, and False Negative (FN) as 0 images. The final accuracy value is 100%. Thus, accuracy, precision, recall, and F1-score values are obtained as follows:
F1-score values are as follows

$$\text{Accuracy} = \frac{46+47}{43+47+7+0} x100\% = 0{,}93\%$$

$$\text{Precision} = \frac{46}{46+7} = 0{,}87$$

$$\text{Recall} = \frac{46}{46+0} = 1$$

$$\text{F1-score} = 2x\,\frac{1.00\,x\,0.87}{1.00+0.87} = 0{,}93$$

From the testing conducted based on a sample of 100 test data, the accuracy rate of the classification confusion matrix in identifying objects is 0.93%.

IV. Conclusion

The creation of a classification model for dicot and monocot leaf images using the Convolutional Neural Network method consists of several stages. Starting from data collection and class distribution, image processing, data augmentation, adding Keras models, convolutional, max-pooling, flatten, relu, dropout, and dense layers. The model is trained for 5 epochs. From the training process, a model with an accuracy of 0.93% is obtained in the experiment with the best accuracy. The validation results using the confusion matrix yield an accuracy rate of 0.93%.

In this study, a dataset with a total of 1000 image files was used. For future research, a larger dataset could be used to achieve even better accuracy results and avoid overfitting and underfitting. Different CNN architectures with varying hyperparameters could be applied in future research.

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