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A Comparative study of Transfer Learning CNN for Flower Type Classification

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Abstract – Flowers are plants that had many types and often found around. But because the many types of flowers, sometimes difficult to distinguish the type from one flower to another. Therefore, in this study, will discuse about the process of identification and classification of flower types, namely daisy, dandelion, rose, sunflower and tulip. The data that would used in this research is image data that consisting of 764 daisy images, 1052 dandelion images, 784 rose images, 733 sunflower images and 984 tulip images. From the total images used, would be divided again into 60% training data, 30% testing data and 10% validation data that would been used to train and evaluate the CNN model. In this study, the classification process has been used transfer learning CNN method using the DenseNet and NasNetLarge architectures, which later from these two architectures would compare to find which architecture is best for classifying flower types. The results that obtained after testing in this study are in the flower classification process using the DenseNet architecture to get a test accuracy of 89% and using the NasLargeNet architecture to get a test accuracy of 86%.

Keywords – Flower, Transfer Learning, CNN, DenseNet, NasLargeNet

1. INTRODUCTION

Flowers are plants that often grow around [1]. That estimated there are at least 369,000 types of flowers that scattered in the world, so with many species that scattered, there are several species flower that have similar characteristics to each other, so making it difficult to identify based on differences in existing flowers in terms of shape, color or texture of the flowers [2,3,4,5]. Roses are a type of flower that is much loved because it has its own fragrance and beauty, so widely used as an ornamental plant, fragrance, and as a raw material for making food or drinks [6]. Sunflower or Heliantus Annuus that is type of flower that is quite often found, estimated to be at least around 23,000 species of sunflowers spread throughout the world [7,8]. Therefore, sunflowers are widely used in the cut flower industry and also the ornamental plant industry [9,10]. Daisy flowers are flowers that had the same structure as sunflowers and often used in the cut flower industry [11]. Dandelion flowers are flowers that been part of Taraxacum which have distinctive characteristics that is purple, yellow, blue and white [12]. Tulips are a type of plant that needs to receive longer light to flower faster [13,14].

Due to perform the classification process, this research would using deep learning method. Deep learning is method of machine learning and artificial intelligence that uses the concept of artificial neural networks, where the artificial neural networks carry out the process of increasing and manipulating data, performing efficiency in training and improving

performance during the training process [15,16]. So deep learning methods are very good for use in processing complex data for performing segmentation or classification [17,18]. Deep learning can also perform learning effectively by enabling end-to-end learning directly using raw data without processing the data first [19,20]. Therefore, deep learning is very good to used in image processing domainn to obtain information and improve the quality from the image [21,22]. Convolutional Neural Network is an implementation of deep learning that can automatically perform pattern recognition and feature extraction accurately [23,24]. This can be possible because in CNN, there are interconnected neurons that can used to learn data, so the CNN method is very good for image processing [25,26].

In this research, the classification process would been carried out using the CNN deep learning method using the DenseNet and NasLargeNet architectures. The purpose of using the transfer learning method using DenseNet architecture is because the DenseNet method uses the concept of all layers connected until the last layer, so that in DenseNet, the layers that used have information that is also contained in the previous layer, so that the information provided can be more accurate. While the purpose of using the transfer learning method using the NasLargeNet architecture that because this network architecture was created through an automatic search process for the best architecture using the reinforcement learning method, so making it possible to achieve good performance in various image recognition tasks, including image classification and object detection. By using these two architectures, a comparison can be carried out and can know which the best architecture that is good and accurate to perform the flower type classification process.

In previous research that conducted by Navekar et. al [27] in 2020 discussed the flower classification process using CNN and CNN transfer learning. The purpose from this research is to build CNN and transfer learning CNN models that can be used to carry out the flower classification process to help the Argiculture industry. The results that obtained after testing in this study are using the CNN method can help improve the marketing process to be easier because of the automation in carrying out the flower classification process. Research that conducted by Mete et. al [28], discusses about the flower classification using deep CNN and machine learning techniques. The purpose of this research is to create a model that can extract using deep CNN and the classification process with Random Forest, SVM, Multi Layer Perceptron and KNN algorithms. The results that obtained from this research are that flower classification is more efficient using SVM because the decrease in SVM performance is not too significant when compared to other algorithms.

2. RESEARCH METHOD

2.1. Dataset

In this research, the dataset that would been used is in form of images that had .jpg extension. The total dataset that used in this study is 4317 flower images consisting of 764 daisy images, 1052 dandelion images, 784 rose images, 733 sunflower images and 984 tulip images. The visualization of each class from the dataset used is given in Figure 1. From total of 4317 data used, for the deep learning model to perform the pattern recognition process, the dataset is divided into training, validation and testing data. The percentage of data division done is 60% for training data, 10% for validation data and 30% for testing data. Training data used to train the model in recognizing patterns from the given image data. Validation data used to validate model performance during the model training process. Meanwhile, test data used to evaluate the performance of the model in carrying out the flower type classification process, so that it

can be seen which models are good and accurate to be able to carry out the flower type classification process.


daisy rose dandelion


tulip sunflower

Figure 1. Dataset Image for each class

2.2. Convolutional Neural Network and Transfer Learning CNN

Convolutional Neural Network or CNN is implementation of deep learning which can automatically perform pattern recognition and also feature extraction accurately [23,24]. This can be possible because in CNN, there are interconnected neurons that can be used to learn data, so the CNN method is very good for image processing [25,26]. In the process of learning and pattern recognition in CNN, usually uses interconnected layers namely input layer, convolutional layer, pooling layer, fully connected layer and also output layer [29]. The input layer is to enter data for the model to carry out the learning process [30]. Convolutional layer is a layer that used to perform the feature extraction process from the image used [31].

Pooling layer is layer that used to manipulate the dimensions of the image without reducing the information contained in the image [32]. Fully Connected Layer is layer that used for the classification process based on information that had been obtain from the previous layer so that the appropriate class can be determined [33]. While the output layer is a layer used to display the results from the process that had been done [34]. In CNN, to be able to perform the classification process efficiently, you can use the Transfer Learning process. Transfer Learning is the process of reusing previously trained models to be able to do new work so that the learning process can be faster and more optimal [35,36]. Because uses models that have been trained before, Transfer Learning is very well used to train models that only have a small dataset so that the process can be optimized even though it only uses a small dataset [37,38].

2.3. Evaluation performance model

In the process of model development, the model built also needs to be evaluated which aims to see how the model performs after the training, validation and testing process. In this study, the calculation of model performance and evaluation would use Confusion Matrix or can be know as matrix that can used to perform a visualization process based on the results of testing performance of a model [39]. In the confusion matrix, the correct positive, false positive, correct negative and false negative values are defined. Which after finding this value, the accuracy,

precision, recall and f1-score values can be calculated. The calculation of these values is given in points 1, 2, 3 and 4.

$$Accuracy = \frac{Right\ prediction}{Total\ Data}\ x\ 100 \quad (1)$$

$$Precision = \frac{TruePostive}{TruePositive + FalsePostive} \quad (2)$$

$$Recall = \frac{TruePostive}{TruePostive + FalseNegative} \quad (3)$$

$$F1 - Score = 2 * \frac{Precision * Recall}{Precision + Recall} \quad (4)$$

2.4. Proposed Flower Classification

In this research, the system implementation process would use the python programming language, and the Jupyter notebook IDE which used to write programs and compile the results of programs that had been made. For the stages of the classification process carried out, given in Figure 2.

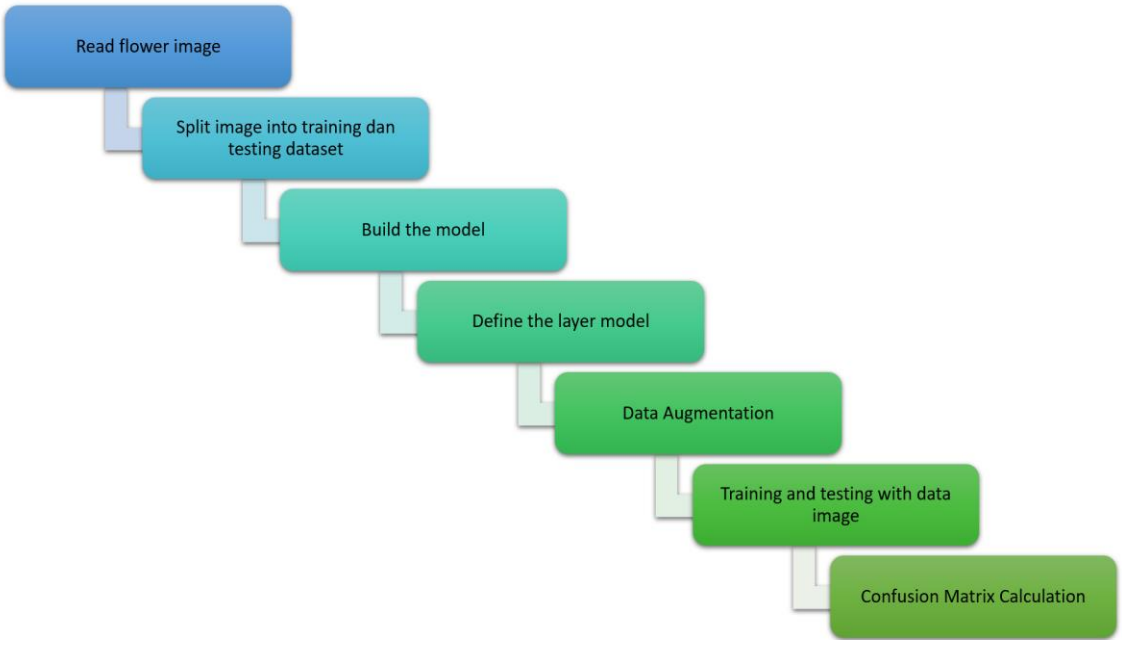
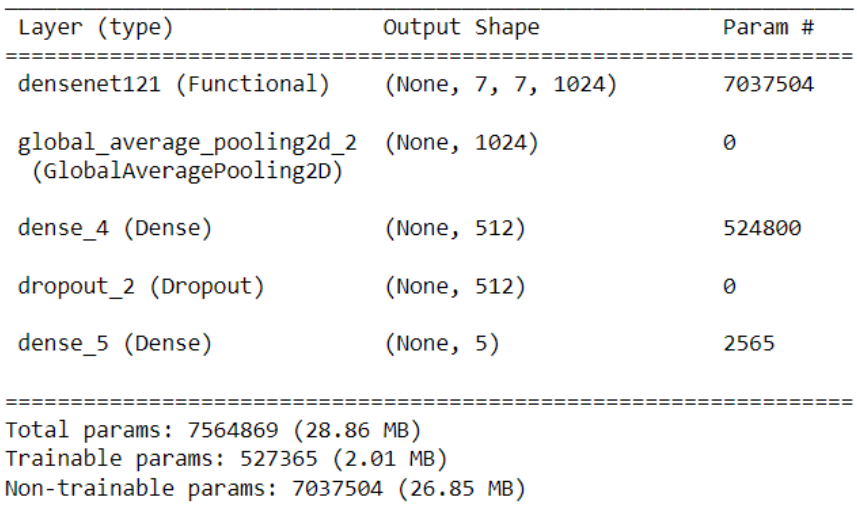


Figure 2. Flower Classification Diagram

The stages of the process carried out had been seen in Figure 2. For an explanation of the process carried out, namely:

1. The process of reading the image that would been used to build the classification model.
2. After reading the dataset in the form of an image, the data is divided into 60% training data, 10% validation data and 30% testing data.
3. Then after the process of reading the dataset and dividing the dataset, the classification model building process will be carried out by initializing the architecture to be used.

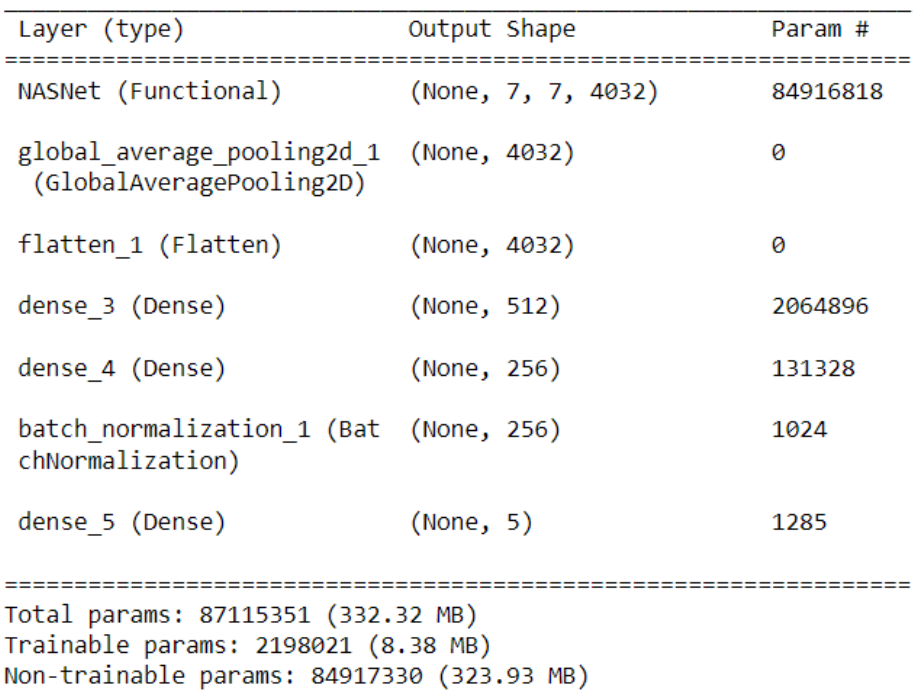
4. After the initialization process of the architecture used, would carry out the process of building layers that would been used to carry out the classification process. The layers used in each model are given in Figures 3 and 4.



Layer (type)	Output Shape	Param #
densenet121 (Functional)	(None, 7, 7, 1024)	7037504
global_average_pooling2d_2 (GlobalAveragePooling2D)	(None, 1024)	0
dense_4 (Dense)	(None, 512)	524800
dropout_2 (Dropout)	(None, 512)	0
dense_5 (Dense)	(None, 5)	2565

Total params: 7564869 (28.86 MB)
Trainable params: 527365 (2.01 MB)
Non-trainable params: 7037504 (26.85 MB)

Figure 3. Layer for DenseNet



Layer (type)	Output Shape	Param #
NASNet (Functional)	(None, 7, 7, 4032)	84916818
global_average_pooling2d_1 (GlobalAveragePooling2D)	(None, 4032)	0
flatten_1 (Flatten)	(None, 4032)	0
dense_3 (Dense)	(None, 512)	2064896
dense_4 (Dense)	(None, 256)	131328
batch_normalization_1 (BatchNormalization)	(None, 256)	1024
dense_5 (Dense)	(None, 5)	1285

Total params: 87115351 (332.32 MB)
Trainable params: 2198021 (8.38 MB)
Non-trainable params: 84917330 (323.93 MB)

Figure 4. Layer for NasNetLarge

5. After the model building process is carried out along with the layers to be used, then the data augmentation process would been carried out which is a process to reduce overfitting by manipulating the image that used for the model building process. In this study, the augmentation data that used is rotation of 40, width shift of 0.25, height shift

of 0.2, shear range of 0.2, zoom range of 0.1, horizontal flip is True and fill mode is nearest.

6. After the preparation process, model building, and data manipulation using data augmentation, the model training process can be carried out to recognize patterns along with the validation process on the model to ensure that the model built does not occur overfitting. Furthermore, after the training and validation process is carried out, the testing process can then be carried out on the model that has been trained and validated previously.
7. Then after the training, validation and testing processes are carried out on the model, then the performance calculation process can be carried out on the model using the confusion matrix and after calculating the performance, so had been seen which model can perform the classification process well.

3. RESULTS AND DISCUSSION

In this study, the classification process would been carried out using an epoch value of 50, a batch size of 32 and early stopping which is monitored by the validation loss value so that the training process will automatically stop when the loss value does not change. The model used would been compiled using a loss method, namely categorical crossentropy, this aims because the data used has a categorical target. The model will also be compiled using the adam optimizer using the metric value in the form of accuracy, because this research would seen the accuracy value of the model. For visualization of training and validation results used is given in Figure 5. Model DenseNet was produced Training Accuracy: 95.58%, Validation Accuracy: 91.09%, Training Loss: 12.66%, and Validation Loss: 27.71%. Whereas in Figure 6, model NasNetLarge was produced Training Accuracy: 94.19%, Validation Accuracy: 86.47%, Training Loss: 17.96%, and Validation Loss: 44.34%.

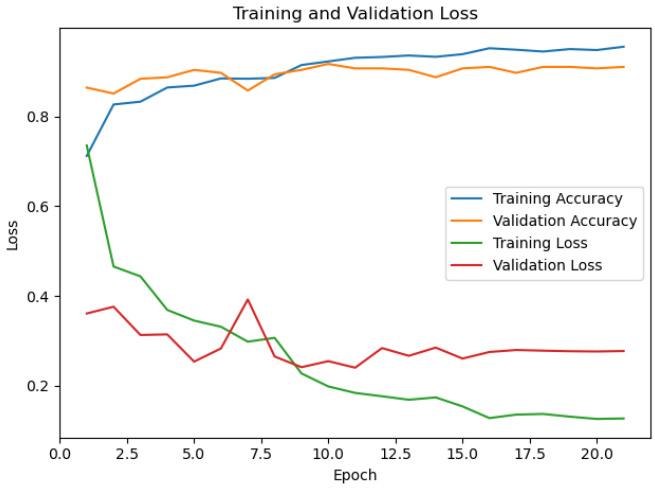


Figure 5. Training and Validation Result using DenseNet

Figure 5 and Figure 6 are shown the classification results by using the Dense Net and Nas Net Large models. From Figure 5 and Figure 6, it had been seen that the training and validation values have the best accuracy using the DenseNet model, with an accuracy of 95.58% and 91.09%. From these values, it had been seen that the classification model using DenseNet

can perform the pattern recognition and learning process well and there is no overfitting because the model had training and validation accuracy values that not had high gap. After the model is carried out the training and validation process, the model testing process can be carried out. The results of the model testing process are given in Table 1.

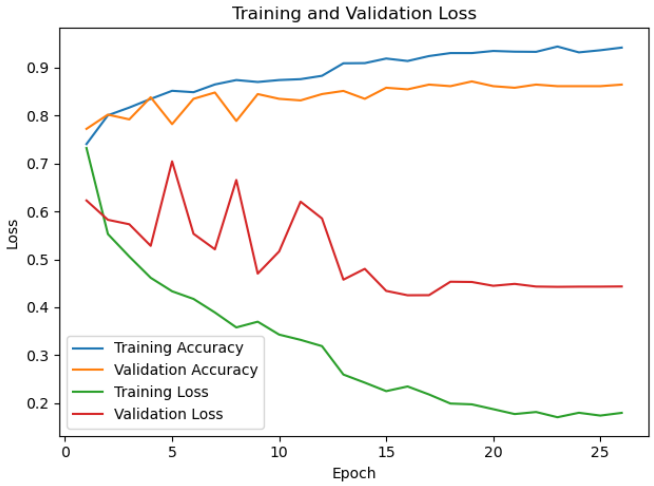


Figure 6. Training and Validation Result using NasNetLarge

Table 1. Result after Testing

Model	Accuracy	Precision	Recall	F1-Score	Support
DenseNet	88.97%	89%	89%	89%	1296
NasNetLarge	86.34%	86%	86%	86%	1296

Table 1 provides the test results that had been obtained after the model testing process is carried out. Had been seen in Table 1, found that the accuracy value when using the model with DenseNet architecture gets a better test accuracy of 89% when compared to a model with NasNetLarge architecture which is 86%. The best precision, recall and f1-score values are also obtained from the DenseNet model, which are 89%, 89% and 89%. These values show that the DenseNet model has good accuracy in making predictions, can perform the classification process accurately and also has a good balance or harmonic value between precision and recall. Many studies have been conducted to classify flower types. Therefore, table 2 gives the results that obtained from previous research studies and comparisons with our research.

Table 2. Result from previous research

Journal	Method	Result
[40]	CNN with VGG16 architecture	80%
Our method	CNN with DenseNet and NasNetLarge architecture	89% and 86%

In Table 2, it had been seen that when compared to previous research that had been done, the research that conducted in this study gets a better accuracy value. This shows that the model with the architecture built in this study can had better and more accurate performance and accuracy to be able to perform the flower type classification process.

4. CONCLUSION

After the training, validation and testing process on the CNN deep learning model, the results show that the best classification process is by using the CNN method with DenseNet architecture, namely with a test accuracy of 89% with a precision value of 89%, a recall value of

89% and an f1-score value of 89%. With the values that have been obtained, it can be concluded that the DenseNet model can be good and accurate in carrying out the flower type classification process. For further research, it is expected to be able to add optimization for hyperparameters so that the values used for dense, epoch values etc. used can be more optimal. In future research, it is also expected to use the transfer learning ensemble process, which combines several transfer learning models to be able to carry out the classification process so that it is hoped that the classification process carried out can be more accurate and efficient.

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