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Classification of beetle type using the Convolutional Neural Network algorithm

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Abstract: Beetles (Order Coleoptera) are the largest order of animals. Beetles are a group of insects that make up the order Coleoptera. Estimates of the total number of living beetle species are millions of beetle species whose features make it difficult to visually identify beetle species. Currently, the beetle classification process is still carried out using direct observation and personal assumptions. CNN model ResNet50 is one of the ResNet variants that has 50 layers and VGG16 is a CNN model that utilizes a convolutional layer with a small convolutional filter specification (3×3) and always uses the same padding and maxpool layers of a 2x2 filter. In this Algorithm (CNN) with the ResNet50 model, it succeeded in exploring beetles with accuracy, precision, recall and F-1 Score with values of 93%, 94.24%, 89.28%, 91.69%, while the VGG16 model succeeded in conducting research on beetle species with accuracy, precision, recall and F-1 Score with values of 86.9%, 87.5%, 87%, 87.2%, so it can be said that the classification of beetle species using the CNN algorithm with the ResNet50 model is better than the VGG16 model.

Keywords: Image Classification; Convolutional Neural Network; ResNet50; VGG16; Beetle; Confusion Matrix

INTRODUCTION

Beetles (Order Coleoptera) are the largest order of animals. Beetles are a group of insects that make up the order Coleoptera. The word "coleoptera" comes from the Ancient Greek, koleos, and pteron, which together mean "sheathed wing". This is because most beetles have two pairs of wings, where the pair in front is called the elytra. Beetles also play an important role as bioindicators of the environment. Some species of beetles can be insect pollinators, predators, seed dispersers and decomposers of plant debris such as leaves and dead trees. [1]

Beetles are usually divided into four suborders namely Archostemata, Myxophaga, Adephaga and Polyphaga. Two morphological features are used to distinguish the suborders, namely the propleuron structure and hindwing venation. [2] Adult beetles can be distinguished from other insects by a series of features where the beetle's most prominent characteristics are having a very hard exoskeleton and forewings that harden to form the elytra. There are many species of beetles, including fruit and flower-eating species, mushroom-eaters, and predators of other invertebrates. Some estimates of the total number of living beetle species are in the millions.

Among the different Deep Learning architectures, Convolutional Neural Network (CNN) is a special kind of Multilayer Neural Network CNN architecture which is inspired by the visual perception of living things. CNN is very suitable for the fields of computer vision and natural language processing [3]. Convolutional Neural Network (CNN) is a deep learning method that is able to carry out the learning process independently to be able to recognize objects, extract objects and classify objects [4].

Many studies related to classification have been carried out, such as the research conducted by Fawwaz., et al in 2021 with the title Race Classification in Cats using the Convolutional Neural Network (CNN) Algorithm. This study classifies breeds in cats using a dataset originating from Oxford-IIIT, totaling 2393 images with a total of 12 classes and the models used are VGG16, InceptionV3, ResNet50 and Xception. The test results obtained in the form of accuracy for each model are 60.85%, 84.94%, 71.39%, and 93.75% [5].

Another study was conducted by Nisfa Fitri Pratiwi in 2020 with the title Classification of Freshwater Fish Species Using Convolutional Neural Networks. In this study, three species of fish were classified, namely tilapia, tilapia, and carp. The method used in this research is Convolutional Neural Network and Local Binary Pattern is used to extract the texture features that exist in the image. This study uses a total of 300 data, 210 images are used as training data and 90 images are used as testing data. After testing in this study, it can be

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concluded that the results of this study are considered good enough in classifying three types of freshwater fish species and can be applied in mobile devices and show that the proposed method is capable of classifying freshwater fish species with an accuracy of 87, 77% [6].

Classification is an important process for recognizing and distinguishing one thing from another, it can be humans, animals, or plants. This identification is done by recognizing the characteristics possessed by something [7]. Based on the above background, the author has the idea to propose a research title with the title "Classification of Beetles using Convolutional Neural Network (CNN) Algorithms".

LITERATURE REVIEW

In a study conducted by Borwarnginn in 2019 research on the classification of races in dogs. The dataset used is 8351 images with 133 races. The method used is Local Binary Patterns (LBP), Histograms of Oriented Gradients (HOG), and CNN with InceptionV3 model using transfer learning. In the experiment of 20 races, the results showed that for each method the accuracy was 62.25%, 79.25%, and 96.75%. In the experiment of 133 races using CNN transfer learning with the InceptionV3, MobileNetV2, and NASNet models, the accuracy results were 89.50%, 89.60%, and 91.00% [8].

In contrast to the research conducted by Wang, Z in 2017 used a dataset from Stanford with a total of 20,580 images with 120 races. Then 2,247 images with 20 races were selected. 80% of the dataset is used for training and 20% is used for testing. The method used is CNN with VGG16, InceptionV3, and Xception models. The results obtained are the accuracy of 84.7%, 93.98%, and 93.89% for each model [9].

There is also a study conducted by Ayanzadeh in 2018 using a dataset originating from Stanford. The number of datasets is divided into 70% for training and 30% for testing. Unlike the two previous works, this work uses fine tuning techniques and data augmentation. The models used are ResNet-50, DenseNet-121, DenseNet-129, and GoogleNet which produce accuracy of 89.66%, 85.37%, 84.01%, and 82.08% [10].

It is also different from research conducted by Atabay to identify races in horses. The dataset is 1693 images with 6 horse breeds. To prevent overfitting, data augmentation and dropout techniques are used. The models used are VGG16, VGG19, InceptionV3, ResNet50, and Xception which produce accuracy of 90.69%, 90.05%, 88.79%, 95.90%, and 93.00%.

In the field of image processing there are several algorithms that can be used including Naïve Bayes, Support Vector Machine, and Neural Network. In line with the development of technology, digital image processing algorithms are developed. One of the developments of deep learning is the Convolutional Neural Network. The study aims to visually classify instagram pages or imagery on screenshots using the Convolutional Neural Network method [11].

CNN has an accuracy test, precision and recall value of 0.88, while the LSTM model has an accuracy test and precision value of 0.84 and a recall of 0.83. In testing the new data input, all of the predictions obtained by CNN are correct, while the prediction results obtained by LSTM have 1 wrong prediction. Based on the evaluation results and the results of testing the new data input, the model produced by the CNN method is better than the model produced by the LSTM method [12].

The deep learning method used is CNN (Convolution Neural Network), where architecture I is designed by the author and architecture II is using VGG16. The results of the accuracy value on architecture I is worth 0.62 and architecture II (VGG16) is worth 0.8. It is concluded that the results of the classification process with VGG16 have a fairly good level of accuracy compared to architecture I [13].

METHOD

In this study, researchers used datasets obtained from https://www.kaggle.com/datasets/kmldas/insect-identification-from-habitus-images. This study will classify 5 types of beetles including Carabus nemoralis O.F Muller, Cicindela campestris Linnaeus, Elaphrus riparius, Harpalus rubripes, and Loricera pilicornis.

This research was conducted using a qualitative research type by applying the Convolutional Neural Network Algorithm method to assist users in classifying the types of beetles

The general research steps can be seen in Figure 1.

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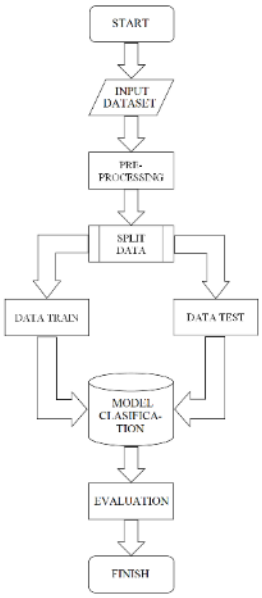

Fig. 1 Convolutional Neural Network Research Steps

The steps of this research work procedure are shown in the flow below.

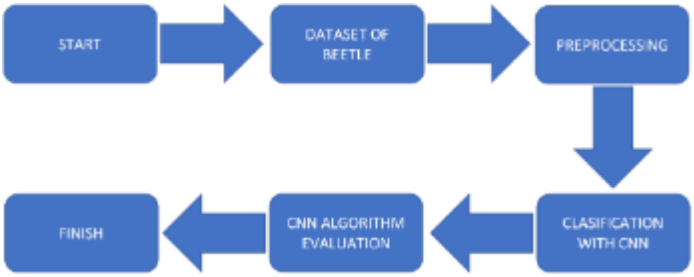

Fig. 2 Work procedures

a. Beetle Type Dataset
   The dataset used for the classification of beetle species was obtained from https://www.kaggle.com/datasets/kmldas/insect-identification-from-habitus-images.
b. Preprocessing
   Preprocessing is the process of cropping, scaling, and grayscalling the dataset that has been provided
c. Classification with CNN
   Classification of beetles using CNN
d. CNN Algorithm Evaluation
   Evaluation of the CNN Algorithm to find out the results of the classification of beetle species

RESULT

The trial steps to classify the type of beetle using the CNN algorithm can be seen as follows:

1. The training process, where at this stage training will be carried out on the data that has been prepared previously using the CNN model. The trained model will then be used to measure how good the algorithm is at identifying
2. The testing process, this stage is quite important because at this stage the program that has been built and in the previous training is tested. The data that has been prepared for testing is then tested using a previously trained model.
3. Development of learning parameters, at this stage a comparison of the accuracy obtained by changing several learning parameters such as epoch, learning rate and image size will be displayed.

One of the most important parts of the successful identification of this image-based beetle species is that the training results obtained are quite good. The good results from the training process will have a very high impact on the results obtained in the trial process later. After the architecture is formed and the model fitting process is carried out, the algorithm will immediately conduct training on the previously prepared data. This study used

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1500 data for 5 beetle species. The training data used for each species is 210 data and the data tested is 90 data for each species, so the total data used is 1050 data for training and 450 data for testing.

(a) Image dataset of Carabus Nemoralis O.F Muller
(b) Image dataset of Cicindela Campestris Linnaeus
(c) Image dataset of Elaphrus Riparius
(d) Image dataset of Harpalus Rubripes
(e) Image dataset of Loricera Pilicornis

Fig. 3 Beetles Dataset

The iteration parameters carried out in this training process are 20 epochs. So the training process will take place and be repeated 20 times to obtain feature extraction from the required features. Then the learning rate value used in this training process is 0.001. This learning rate value is used to update the weights each time the algorithm performs a backward-pass process.

a. Models ResNet50
ResNet-50 is a variant of ResNet which has 50 layers [14]. If the previous ResNet version went through 2 layers, then ResNet-50 went through 3 layers and there was 1x1 convolution layer. [15]

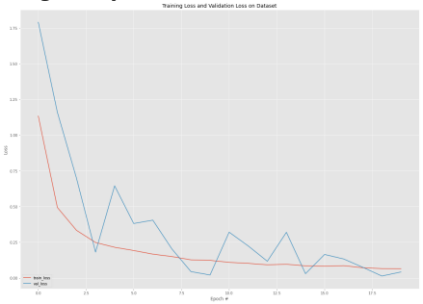

Fig. 4 Loss Evaluation Results in the ResNet50 Training & Validation process

The red line in Figure 4 represents the training loss, which is the percentage of error in the training data. While the blue line is Validation Loss, which is an error that occurs after running validation data. So, it can be seen in Figure 4 that the greater the Epoch value, the smaller the resulting Validation Loss value. However, Epoch is the number of training processes carried out. Thus, the more Epoch values, the time needed to carry out the training process will also increase. On the other hand, the Validation Loss value is quite low at four Epoch points, including 4, 9, 15, and 19

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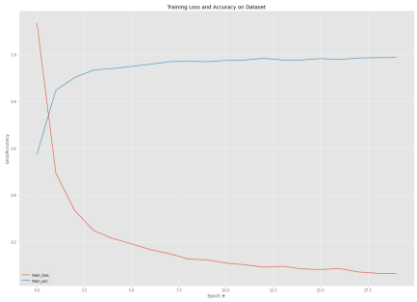

Fig. 5 Loss & Accuracy Evaluation Results in the ResNet50 Training process

Figure 5 shows the comparison between the Loss value and accuracy when training the algorithm. In this case the results of Loss and accuracy show good results.

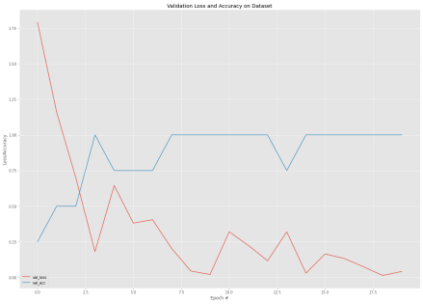

Fig. 6 Loss & Accuracy Evaluation Results on the ResNet50 Validation process

While in Figure 6 it can be seen that the results of Loss and accuracy in the Validation process are not as good as the results of the training. These results are considered quite reasonable because in the training process the algorithm can predict the same data over and over again. Meanwhile, in the validation process, the algorithm will experience difficulties because it predicts new data that has not been trained before.

Table 1 displays the evaluation data in Figures 5 and 6 which show that the accuracy produced is quite good and some epochs have good and quite low loss results. The total number of epochs is 20. In the Training and Validation process, although the algorithm manages to predict quite well. However, this does not mean that the model has succeeded in predicting well.

Table 1. ResNet50 Training Evaluation and Validation Table

Epoch	Training Loss	Training Accuracy	Validation Loss	Validation Accuracy
1	1,1333	0,5740	1,7898	0,2500
2	0,4938	0,8473	1,1602	0,5000
3	0,3340	0,9020	0,6994	0,5000
4	0,2487	0,9340	0,1814	1,0000
5	0,2151	0,9400	0,6452	0,7500
6	0,1925	0,9493	0,3814	0,7500
7	0,1672	0,9587	0,4051	0,7500
8	0,1503	0,9693	0,2035	1,0000
9	0,1273	0,9720	0,0449	1,0000
10	0,1237	0,9693	0,0213	1,0000
11	0,1098	0,9747	0,3208	1,0000
12	0,1027	0,9767	0,2245	1,0000
13	0,0926	0,9840	0,1174	1,0000
14	0,0964	0,9767	0,3202	0,7500
15	0,0854	0,9767	0,0304	1,0000
16	0,0824	0,9827	0,1649	1,0000
17	0,0866	0,9787	0,1335	1,0000
18	0,0720	0,9853	0,0752	1,0000
19	0,0662	0,9867	0,0141	1,0000

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20	0,0659	0,9880	0,0423	1,0000

b. VGG16 models

VGG16 is one of the models of Convolutional Neural Network which has a convolutional filter layer of 3x3 and always uses the same padding layer and maxpool of a 2x2 filter. This model follows convolution and max pool layer settings consistently across the architecture. In the end it has 2 FC (fully connected layers) followed by softmax for output. 16 in VGG16 refers to the 16 layers that have weight in this architecture.

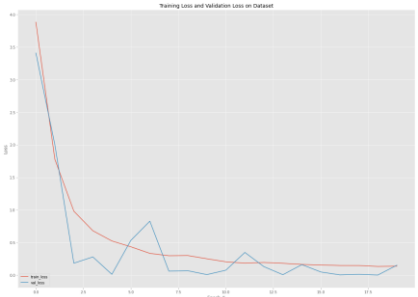

Fig. 7 Loss Evaluation Results in the VGG16 Training & Validation process

The red line in Figure 7 represents the training loss, which is the percentage of error in the training data. While the blue line is Validation Loss, which is an error that occurs after running validation data. So, it can be seen in Figure 7 that the greater the Epoch value, the smaller the resulting Validation Loss value. However, Epoch is the number of training processes carried out. Thus, the more Epoch values, the time needed to carry out the training process will also increase. On the other hand, the Validation Loss value is quite low at four Epoch points, including 1, 7, 12, and 20.

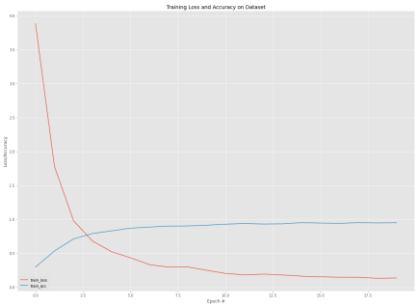

Fig. 8 Loss and Accuracy Evaluation Results in the VGG16 Training process

Figure 8 shows the comparison between the Loss value and accuracy when training the algorithm. In this case the results of Loss and accuracy show good results

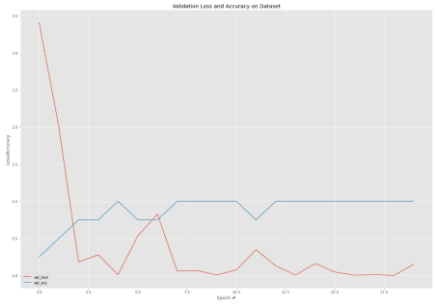

Fig. 9 Loss/Accuracy Evaluation Results in the VGG16 Validation process

While in Figure 8 it can be seen that the results of Loss and accuracy in the Validation process are not as good as the results of the training. These results are considered quite reasonable because in the training process the algorithm can predict the same data over and over again. Meanwhile, in the validation process, the algorithm will experience difficulties because it predicts new data that has not been trained before.

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Table 2 displays the evaluation data in Figures 7 and 8 which show that the accuracy produced is quite good and some epochs have good and quite low loss results. The total number of epochs is 20. In the Training and Validation process, although the algorithm manages to predict quite well. However, this does not mean that the model has succeeded in predicting well

Table 2. VGG16 Training Evaluation and Validation Table

Epoch	Training Loss	Training Accuracy	Validation Loss	Validation Accuracy
1	3,8824	0,2967	3,4090	0,2500
2	1,7782	0,5340	2,0020	0,5000
3	0,9805	0,7120	0,1822	0,7500
4	0,6805	0,7913	0,2783	0,7500
5	0,5236	0,8307	0,0114	1,0000
6	0,4340	0,8700	0,5324	0,7500
7	0,3330	0,8867	0,8273	0,7500
8	0,2965	0,9000	0,0602	1,0000
9	0,2994	0,9027	0,0664	1,0000
10	0,2501	0,9133	0,0066	1,0000
11	0,2036	0,9287	0,0746	1,0000
12	0,1822	0,9393	0,3473	0,7500
13	0,1932	0,9307	0,1296	1,0000
14	0,1807	0,9340	0,0052	1,0000
15	0,1631	0,9513	0,1600	1,0000
16	0,1545	0,9453	0,0470	1,0000
17	0,1470	0,9400	0,0025	1,0000
18	0,1463	0,9520	0,0100	1,0000
19	0,1322	0,9467	0,0715	1,0000
20	0,1366	0,9507	0,1514	1,0000

Table 3. Table of Test Results for Each Model

Model	**Training**	**Testing**
ResNet50 + Augmentasi	94,13%	86,25%
VGG16 + Augmentasi	85,28%	87,50%

After testing, the best accuracy results for each model are obtained in table 3. Of these models, the best result is the ResNet50 model with training accuracy of 94.13% and testing accuracy of 86.5%.

Table 4. Table of Confusion Matrix

	Positive (Predicted Class)	**Negative (Predicted Class)**
Positive (True Class)	TP (True Positive)	FN (False Negative
Negative (True Class)	FP (False Negative)	TN (True Negative)

Table 4 is table of confusion matrix when

a. True Positive is the number of positive data correctly classified by the system.
b. False Negative is the number of negative data incorrectly classified by the system.
c. True Negative is the number of negative data correctly classified by the system.
d. False Positive is the number of positive data incorrectly classified by the system.

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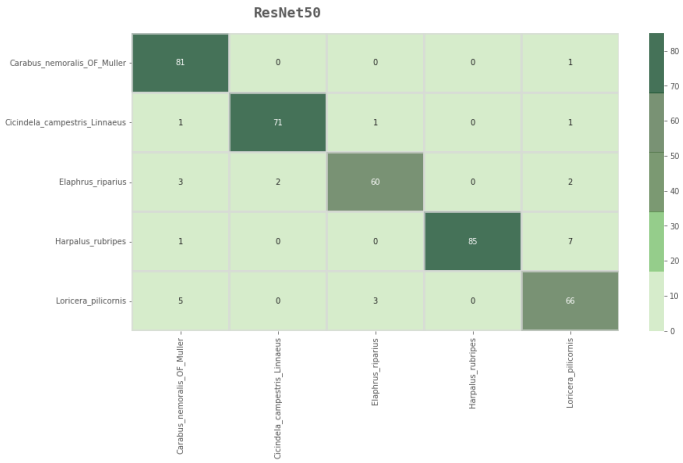

Fig. 10 Confusion Matrix ResNet50

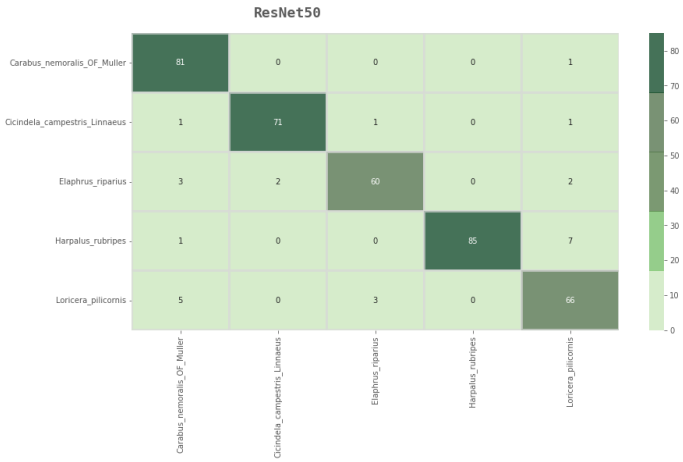

Fig. 11 Confusion Matrix VGG16

In Figure 10 we can see the results of the confusion matrix on the ResNet50 and VGG162. from Figure 9 get the values of TP, TN, FP, FN from each model. So we calculate the Accuracy, Precision, Recall and F1 Score of each model by using the following formula.

$$Accuracy = \frac{TP}{TP+FN} * 100\% ,$$

$$Precision = \frac{TP}{FP+TP} * 100\% ,$$

$$Recall = \frac{TP}{FN+TP} * 100\% ,$$

$$F1\ Score = \frac{2 * (Presisi * Recall)}{Presisi + Recall} * 100\%$$

Table 5. Result of Accuracy, Precision, Recall and F1 Score on ResNet50 and VGG16 models

Model	Accuracy	Precision	Recall	F1 Score
ResNet50 + Augmentasi	93%	94,24%	89,28%	91,69%
VGG16 + Augmentasi	86,90%	87,50%	87%	87,20%

DISCUSSIONS

Convolutional Neural Network (CNN) algorithm is a deep learning algorithm that focuses on studying the characteristics of an object in more depth. One of the most important parts of the success of this algorithm to

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classify an object is the large amount of data. The more data that is trained in the training process, the higher the results obtained. Vice versa, this CNN algorithm will not be optimal when the data is trained with little data.
In this study, the Convolutional Neural Network (CNN) Algorithm with the ResNet50 model succeeded in identifying the type of beetle with accuracy, precision, recall and F-1 Score with values of 93%, 94.24%, 89.28%, 91.69%, while the VGG16 model succeeded in performing identification of beetle species with accuracy, precision, recall and F-1 Score with values of 86.9%, 87.5%, 87%, 87.2%. In identifying the type of beetle, the results obtained in this study were considered to be quite optimal.
CNN algorithm is a good algorithm for identifying beetle species. Coupled with the independence of the algorithm, which actually does not require feature extraction anymore, because there is already a feature learning process in it.

CONCLUSION

The conclusions from the research conducted by the author are as follows in this study, the Convolutional Neural Network (CNN) Algorithm with the ResNet50 model succeeded in identifying the type of beetle with accuracy, precision, recall and F-1 Score with values of 93%, 94.24%, 89.28%, 91.69%, while the VGG16 model was successful. to identify beetle species with accuracy, precision, recall and F-1 Score with values of 86.9%, 87.5%, 87%, 87.2%. In this study it can be concluded that the classification of beetle species using the cnn algorithm with the ResNet50 model is better than the VGG16 model.

REFERENCES

[1] Depari E, Dirhamsyah., Darwati H. (2021). Identifikasi Jenis Kumbang (Coleoptera) di Hutan Sekunder Desa Ladangan Kecamatan Menyuke Kabupaten Landak. J Hutan Lestari.,9(3),475–84.
[2] Apriyani S, Wahyuni S, & Azzumar P M. (2021) "KERAGAMAN HAMA PADA PERTANAMAN BAWANG MERAH (Allium ascalonicum L.) DI KABUPATAN PATI". Jurnal Litbang Provinsi Jawa Tengah, 19(1), 13–20.
[3] Ghosh, A., Sufian, A., Sultana, F., Chakrabarti, A., & De, D. (2019). Fundamental concepts of convolutional neural network. Intelligent Systems Reference Library, 172, 519–567.
[4] Arrofiqoh, E. N., & Harintaka, H. (2018). Implementasi Metode Convolutional Neural Network Untuk Klasifikasi Tanaman Pada Citra Resolusi Tinggi. Geomatika, 24(2), 61.
[5] Afif, M., Fawwaz, A., Ramadhani, K. N., & Sthevanie, F. (2020). Klasifikasi Ras pada Kucing menggunakan Algoritma Convolutional Neural Network (CNN). Jurnal Tugas Akhir Fakultas Informatika, 8(1), 715–730.
[6] Pratiwi, N. F. (2020). Klasifikasi Spesies Ikan Air Tawar Menggunakan Convolutional Neural Network. Engineering, Construction and Architectural Management, 25(1), 1–9.
[7] Yunita Y, (2020). Klasifikasi Gambar Menggunakan Metode K-Nearest Neighbor Image Classification Using K-Nearest Neighbor Method. Semin Nas Teknol Inf dan Komun, 451–7.
[8] Borwarnginn P, Thongkanchorn K, Kanchanapreechakorn S, Kusakunniran W. Breakthrough Conventional Based Approach for Dog Breed Classification Using CNN with Transfer Learning. In 2019 11th International Conference on Information Technology and Electrical Engineering.
[9] Wang Z, Zhao D, Hong K. “PROJECT DOG BREED CLASSIFICATION.” Radio Sci. 2017
[10] Ayanzadeh, A., & Vahidnia, S. (2018). Modified Deep Neural Networks for Dog Breeds Identification. Preprints.
[11] Kholik A. (2021). Klasifikasi Menggunakan Convolutional Neural Network (Cnn) Pada Tangkapan Layar Halaman Instagram. JDMSI, 2(2), 10-20, ISSN: 2745-8458.
[12] Kurniawan AA, Mustikasari M. Implementasi Deep Learning Menggunakan Metode CNN dan LSTM untuk Menentukan Berita Palsu dalam Bahasa Indonesia. J Inform Univ Pamulang. 2021;5(4):544.
[13] Maulana FF, Rochmawati N. Klasifikasi Citra Buah Menggunakan Convolutional Neural Network. J Informatics Comput Sci. 2020;1(02):104–8.
[14] Akbar SNAF, Hendra, Supri Bin Hj. Amir. Perbandingan Kinerja Arsitektur Inception-V4 Dan Resnet-50 Dalam Mengklasifikasikan Citra Paru-Paru Terinfeksi Covid-19. 2020;2.
[15] Akbar SNAF, Hendra, Supri Bin Hj. Amir. Perbandingan Kinerja Arsitektur Inception-V4 Dan Resnet-50 Dalam Mengklasifikasikan Citra Paru-Paru Terinfeksi Covid-19. 2020;2

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