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# Comparison of Convolutional Neural Network and Artificial Neural Network for Rice Detection

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**Abstract:** Rice is a staple food for people in tropical countries. Indonesia is a country that needs a lot of rice for its people in providing food. This country has implemented various ways to plant rice properly. Many agricultural fields have implemented harvests up to three times a year, due to the role of technology which has helped a lot in agriculture. Planting to harvest already uses advanced technology and tools. A good rice harvest can improve the welfare of the surrounding community. Meanwhile with lots of rice products because many rice plants produce with lots of rice. The type of rice from different regions of origin, the yield of rice is also different from other regions of origin. But with advances in technology, it is possible to plant rice whose types of plants come from other regions. The rice sold to the public varies, so that people who are unfamiliar with the types of rice find it difficult to detect the types of rice. Machine learning is present in detecting various kinds of rice. Machine learning, especially deep learning can make better detection, because one of the deep learning methods works similar to the human brain. In the human brain there are millions or even billions of neurons. This research uses neural networks in experiments using public datasets. Experiments using Artificial Neural Networks achieve an training accuracy of 98.2%, loss: 0.2351. It takes about 10 minutes of training. Testing accuracy reaches accuracy: 96%, loss: 0.6641. By conducting experiments using the Convolution Neural Network, it achieves an accuracy of 99.3% and the training time requires around 18 hours. The purpose of this research is to classify the rice image dataset and detect the rice image.

**Keywords:** Artificial Neural Network; Convolutional Neural Network; Detection; Deep Learning; Machine Learning; Rice

## INTRODUCTION

The need for food for the Indonesian state in one year is very urgent, this encourages farmers to plant rice and take good care of it. Starting from watering, applying fertilizer, to reducing pests. From the existing agricultural process, it is hoped that agricultural output, especially rice, can increase as the farmers hope. Technology that has helped agriculture today has involved drones. Drones are used for spraying pests and diseases. In addition, technology that can be Internet of Things has been widely applied in managing agricultural products. Climate and weather need to be anticipated and utilized by farmers. Rainfall is falling and weather agencies are already providing data for farmers. Unfortunately, the farmers have not been able to take advantage of the information from the government through the agency that monitors the weather.

In terms of harvest, sometimes farmers are always disadvantaged by the emergence of imported rice, where the price of grain will fall before the harvest. This incident makes farmers who are struggling hard as if they are helpless in dealing with problems like this. Because there are some farmers who have used Internet of Things technology in solving agricultural problems. Internet of Things devices are already very cheap when applied to agricultural land. Such as detection of leaf diseases in rice with the help of micro-controller devices, pest detection and others. Disease detection can be used using machine learning or deep learning. Machine learning has been widely used as a tool for modeling. Where at this time the model can be embedded into the micro-controller device (Sze, Hindarto, et al., 2022). An implantable device such as a Raspberry Pi, Arduino or Esp32 equipped with a camera. In terms of price, micro-controller devices are already cheap and because of that,

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several devices have appeared that can connect to the internet as a means of communication. The device is called the Internet of Things (IoT) device. The use of IoT devices, farmers hope will increase their agricultural output. Monitoring of pests and diseases is easier. Plants can be monitored, whether the plants lack water and others. In essence, the use of technology is very helpful for farmers in managing agricultural land.


Fig. 1 Rice grown in Indonesia
**Source: Google Image**

Fig 1 is an agricultural product in the form of rice and rice plants producing fertile rice plants and rice grain. Rice grain will be quality if the care of fertile rice plants. Fertile rice production produces good quality grain or rice. Because rice products vary, it is sometimes difficult to distinguish between types of rice. If you can see the appearance of rice in fig 1, humans without using tools or devices can tell the difference. Fig 1, in terms of color, humans can immediately recognize it.

The problem that arises after many images of rice with small differences. The colors are both white, but there are differences in shape and size. There is white rice, the other rice is oval in shape and the other is slightly round in shape. With these problems, this research aims to find solutions so that detection of rice can be carried out, using deep learning algorithms. The algorithms chosen in this research are Convolutional Neural Networks (Sze, Santoso, et al., 2022), (Hindarto & Santoso, 2019) and Artificial Neural Networks. This explanation raises a research question for this study. Research Question 1, How to get a dataset for an experiment to make rice detection? Research Question 2, What algorithm will be used in this research? Research Question 3, How many algorithms will be compared? Research Question 4, How are the two algorithms different in terms of accuracy and training time?

## LITERATURE REVIEW

There has been a lot of research that has discussed classification using deep learning. Especially deep learning which is supervised learning. The literature review in this research reviews research using the Convolutional Neural Network and Artificial Neural Network algorithms. The advantages and disadvantages of the research are presented in table 1, but the accuracy and loss are also presented.

Table. 1 List of previous research discussing CNN and ANN

| Ref | Title | Strength | Weakness |
|---|---|---|---|
| (Wulandari et al., 2020) | Classification of Digital Image of Spices and Spices with Convolutional Neural Network (CNN) Algorithm | Research uses CNN in classifying herbs and spices. The training data accuracy value is 0.9875 and the loss value is 0.0769. The accuracy value of the testing data | The dataset used in the training uses a small dataset, a total of 300 images. The dataset is divided into three categories, namely Ginger, Ginseng and |

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| | | | |
|---|---|---|---|
| | | is 0.85 and the loss value is 0.4773. Meanwhile, testing with new data, namely 3 images for each category, resulted in an accuracy of 88.89%. | Galangal. |
| (Fonda, 2020) | Riau Batik Classification Using Convolutional Neural Networks (CNN) | This research classifies batik with two types of batik, namely Riau batik and non-Riau batik. The classification uses the Convolutional Neural Network (CNN) algorithm. Accuracy from training to model, around 65%. | The image dataset used is 168 images. It consists of 100 non-batik image datasets and 68 Riau batik image datasets. |
| (Nugroho & Puspaningrum, 2021) | Performance of the CNN Method for Classifying Pneumonia with Variations in Input Image Size. | This research uses public datasets from kaggle.com as a reference for data scientists. The dataset used is pneumonia data. CNN method modified with Extreme Learning Machine (ELM). Training accuracy reaches about 65%. | The dataset was taken from the kaggle.com website, with a total of 1,583 normal images and 4,237 pneumonia images. |
| (Sze, Santoso, et al., 2022) | Review Star Hotels Using Convolutional Neural Network | This research uses public datasets and private datasets. Doing a mix of datasets aims to improve performance accuracy by using the Convolutional Neural Network algorithm. Achieves an accuracy of about 98.48% accuracy and loss reaches 0.0554. | Using a dataset of 503 images by distributing datasets for 5 image classes, namely one-star, two-star, three-star, four-star and five-star hotels. |

The research in table 1 explains that a lot of research has discussed the Convolutional Neural Network algorithm by solving cases of batik detection, spice detection, and star hotel detection. Each research process uses a relatively small dataset in the number of image datasets. There is a question how the Convolutional Neural Network algorithm with relatively large data. On that basis there is a gap in terms of the number of datasets. State-of-the-art in this research performs classification with the Convolutional Neural Network algorithm using a relatively large dataset of 15,000 for the total image. This research aims not to find weaknesses from previous research discussing the classification of Convolutional Neural Networks, but this research is to complement previous research which has discussed Convolutional Neural Networks..

## METHOD

Machine learning is a branch of Artificial Intelligence (Garrido, 2010). Machine learning in carrying out processes focuses on data. Therefore in machine learning algorithms always rely on datasets. Before carrying out the machine learning process, it performs dataset preparation, performs feature extraction and conducts learning whose results include classification, prediction and others. Whereas deep learning does the process of not performing feature extraction, all of that is done by deep learning. Unlike deep learning, machine learning still

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has human intervention, such as dataset preparation, dataset extraction features. Algorithm selection in this research uses Artificial Neural Network and Convolutional Neural Network algorithms.

The dataset used in this research uses a public dataset, because the local rice dataset is not as large as the number of rice image datasets (Suryawanshi et al., 2022), (Özkan, 2022) available in public. The research deliberately uses a rather large image dataset (Mavromatis et al., 2022) of around 15,000 image datasets. Which consists of Arborio, Basmati, Ipsala, Jasmine, Karacadag classes. The number of each image dataset is 5000 images. The dataset is taken from kaggle.com, the kaggle website is a reference for research in the field of machine learning and deep learning. The image dataset is downloaded and then separated into each folder according to each class. The image dataset grouping consists of five image classes. So that in selecting the appropriate algorithm is the supervised learning algorithm. Labels or targets based on five folders. So indirectly the dataset has five classes. It is very possible for further research by providing rice plant datasets and rice datasets for products from Indonesia as research for agriculture. Because Indonesia is a rice producer and there are so many types of rice in Indonesia.

Artificial Neural Network (Saldarriaga, 2022) is a deep learning algorithm that performs training based on the input layer, hidden layer and output layer. A neural network is a model that has been developed to work like the human brain. Neurons in the human brain, the neurons are interconnected and transmit information. Can be seen in Fig. 2 about the mathematical formulation of a neural network (Seawram et al., 2022). Where $x_0$ is given the weight $w_0$, then it produces $w_0x_0$, $x_1$ is given the weight $w_1$, then it produces $w_1x_1$, and $x_2$ is given the weight $w_2$, then it produces $w_2x_2$. Then the equation function becomes $\sum_i$ wi xi + b, where b is the bias

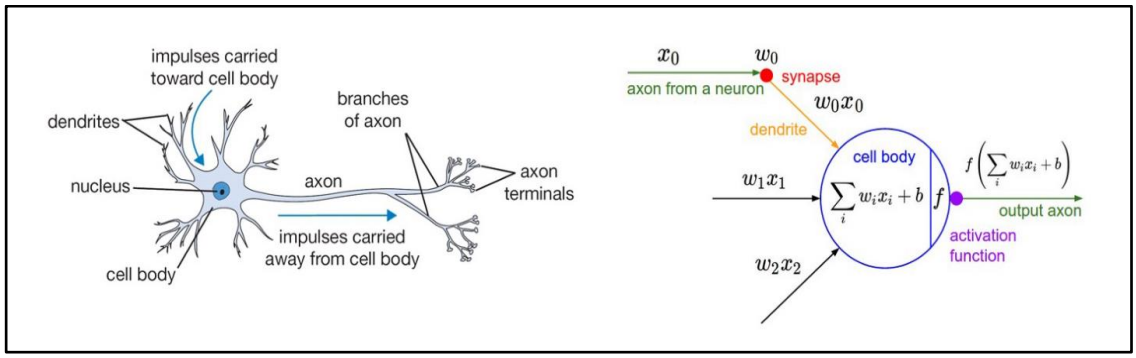


Fig. 2 Illustration of Neurons and Neural Network Mathematical Models
**Source: Stanford Course**

On fig. 3 explains the multilayer perceptron which processes the input layer, hidden layer 1, hidden layer 2, and output layer. This illustration is the basis for creating an Artificial Neural Network algorithm.

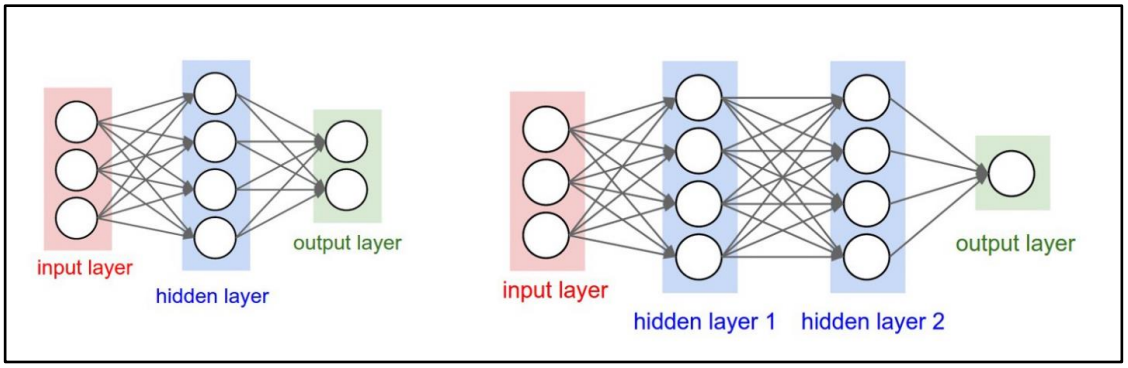


Fig. 3 Illustration of a Multi-Layer Perceptron
**Source: Stanford Course**

Convolutional Neural Network, before discussing Convolutional Neural Networks (CNN) (Wu, 2017), everyone is very familiar with vectors and matrices. Suppose a vector $\mathbf{X} \in R^D$, where D is a column vector with D elements. The letters in D are matrices. Suppose there is a notation: $\mathbf{X} \in R^{H \times W}$ is a matrix with H as rows and W as columns. Vector X can also be called a matrix that has 1 column and row D.

This concept can be generalized into a high-level matrix called a **Tensor** (Wu, 2017). For example $X \in R^{H \times W \times D}$ is a tensor of order 3. It contains elements H, W, D, and each is called index (i, j, d), where the values of I, j, and d are as follows , $0 \leq i < H$, $0 \leq j < W$, and $0 \leq d < D$. These are called the order 3 tensors and are the

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contents of matrix D. Each matrix is a channel of a matrix with size H × W. The first channel contains all the numbers in a tensor indexed by (i, j, 0). When D = 1, then the 3rd order tensor is reduced to a matrix.

In interacting with tensors on a daily basis, the Scalar Values in tensors are of the order of zero. Vector is first order, and matrix is second order. To clarify about Tensors, an example is Fig. The colored image is a 3rd order tensor. An image with H rows and W columns is a tensor with size H × W × 3. If a color image is saved in RGB format, then the Image has 3 channels (R, G and B). Each channel is an A Matrix with H × W (second order tensor) containing the (R, G, B) values of all pixels (Wu, 2017).

The explanation above regarding the image can be referred to as a tensor. Computer vision with pattern recognition and color images which are order 3 tensors, often converted to gray scale versions as matrices. Much better way of doing matrix management than tensors. But the information in color images is always lost during this conversion. However, color becomes very important as a problem of image or video-based learning and recognition. Color problems can be solved with the **Convolutional Neural Network algorithm** (Coulibaly et al., 2022)**,** (Chen & Ge, 2022), (Walle et al., 2023).

Tensors are very important in the Convolutional Neural Network algorithm. Inputs, intermediate representations, and parameters in a Convolutional Neural Network are tensors. A tensor that has a higher order than 3 is widely used in Convolutional Neural Network algorithms.

Convolutional Neural Network (Djenouri et al., 2023), in carrying out the input it uses a sequence of 3 tensors. Image with H row, W column, and 3 channels (R, G, B). For high-order tensor (matrix) input, it can be processed by the Convolutional Neural Network in the same way. Furthermore, the input sequentially goes through a series of processing. Layer is a processing step, which can be a convolution layer, pooling layer, normalization layer, fully connected layer, loss layer, and others. The following is the equation of the details of the layers.

$$\mathbf{x}^1 \rightarrow \mathrm{w}^1 \rightarrow \mathbf{x}^2 \rightarrow \cdots \rightarrow \mathbf{x}^{L-1} \rightarrow \mathbf{w}^{L-1} \rightarrow \mathbf{x}^L \rightarrow \mathbf{w}^L \rightarrow \mathrm{z} \qquad (1)$$

The equation in (1) is an illustration of how the Convolutional Neural Network algorithm works layer by layer in a forward pass. The input is x1, as an image with a sequence of 3 tensor.
The last layer is the loss layer. Suppose t is the appropriate target value for input x1, then the loss function can be used to measure the difference between the prediction of the Convolutional Neural Network xL and the target t. The function has the following equation:

$$\mathrm{z} = \frac{1}{2} \| \mathrm{t} - \mathrm{x}^L \|^2 \qquad (2)$$

In detail, the three types of layers of the Convoluitonal Neural Network algorithm are convolution, union, and ReLU. These three parts are important components in a Convolutional Neural Network. Precise normalization or batch normalization is an optimization process for learning parameters in a Convolutional Neural Network.

## RESULT

Experiment Setup. In this study we used an Acer Core i9 with 32 GB of RAM, 512 GB SSD Storage, GPU RTX 3060. The dataset is divided into five folders containing Rice Arborio, Basmati, Ipsala, Jasmine, Karacadag. The dataset is classified using the Convolutional Neural Network Algorithms and Artificial Neural Network Algorithms. The results of the training carried out to get a model with good accuracy and produce a fairly small loss.

Experiments using the Artificial Neural Network Algorithm as in fig 4, were carried out using the Keras library, tensforflow. Using several activations with Relu and SoftMax to classify. At the beginning of the process using adding Dense 64, then Dense 120, and continuing until the Dense becomes small around 5, because the process produces 5 classes for the Arborio, Basmati, Ipsala, Jasmine, Karacadag rice dataset.

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```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense
model = Sequential()
model.add(Dense(64, input_dim = x_train.shape[1], activation = 'relu'))
model.add(Dense(120, activation = 'relu'))
model.add(Dense(100, activation = 'relu'))
model.add(Dense(50, activation = 'relu'))
model.add(Dense(5, activation = 'softmax'))
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense (Dense)               (None, 64)                50240

 dense_1 (Dense)             (None, 120)               7800

 dense_2 (Dense)             (None, 100)               12100

 dense_3 (Dense)             (None, 50)                5050

 dense_4 (Dense)             (None, 5)                 255

=================================================================
Total params: 75,445
Trainable params: 75,445
Non-trainable params: 0
_________________________________________________________________
```

Fig. 4 Artificial Neural Network Architecture
**Source: Researcher Property**

On fig. 5 uses the loss 'sparse_categorical_crossentropy' and uses the 'adam' optimizer for training loss which is relatively very small with an average of 0.12, while validation loss is relatively small around 2.1. Meanwhile, accuracy training has reached 98.2% and accuracy validation has reached 96.2%.

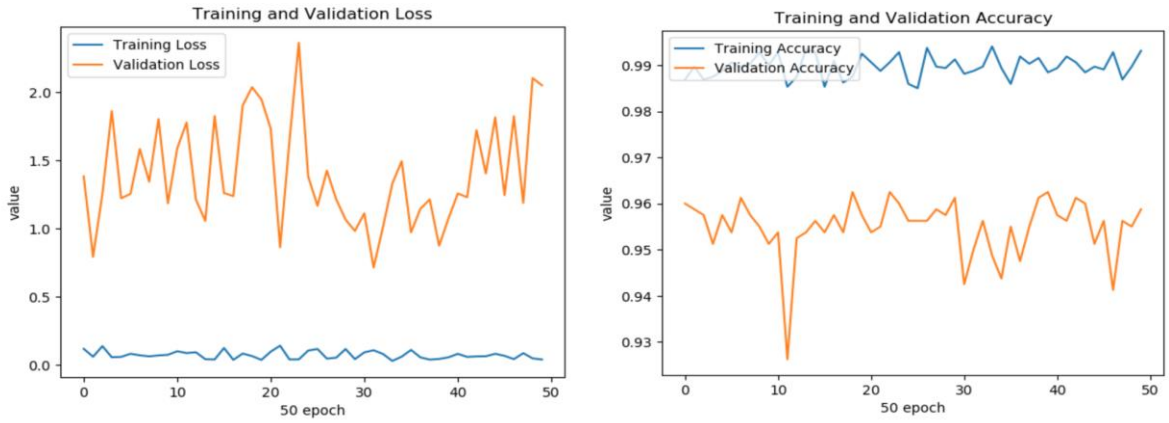


Fig. 5 The training results use the rice dataset with an Artificial Neural Network
**Source: Researcher Property**

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Experiments using the Convolutional Neural Network Algorithm, yielded an accuracy of around 99.3%. And the loss is around 0.023. Training time takes about 18 hours. Because the process uses the CPU, not the GPU. Then the time needed becomes longer. Can be seen in fig. 5.

```
Model Details are :
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 98, 98, 256)       7168

 conv2d_1 (Conv2D)           (None, 96, 96, 256)       590080

 max_pooling2d (MaxPooling2D  (None, 24, 24, 256)      0
 )

 conv2d_2 (Conv2D)           (None, 22, 22, 256)       590080

 conv2d_3 (Conv2D)           (None, 20, 20, 128)       295040

 conv2d_4 (Conv2D)           (None, 18, 18, 64)        73792

 max_pooling2d_1 (MaxPooling  (None, 4, 4, 64)         0
 2D)

 flatten (Flatten)           (None, 1024)              0

 dense (Dense)               (None, 512)               524800

 dense_1 (Dense)             (None, 512)               262656

 dense_2 (Dense)             (None, 256)               131328

 dense_3 (Dense)             (None, 256)               65792

 dense_4 (Dense)             (None, 5)                 1285

=================================================================
Total params: 2,542,021
Trainable params: 2,542,021
Non-trainable params: 0
_________________________________________________________________
None
```

```
epochs = 10
ThisModel = KerasModel.fit(X_train, y_train, epochs=epochs,batch_size=64,verbose=1)
```

```
Epoch 1/10
1055/1055 [==============================] - 4932s 5s/step - loss: 0.2155 - accuracy: 0.9369
Epoch 2/10
1055/1055 [==============================] - 7246s 7s/step - loss: 0.1011 - accuracy: 0.9657
Epoch 3/10
1055/1055 [==============================] - 15713s 15s/step - loss: 0.0797 - accuracy: 0.9741
Epoch 4/10
1055/1055 [==============================] - 19804s 19s/step - loss: 0.0692 - accuracy: 0.9781
Epoch 5/10
1055/1055 [==============================] - 3922s 4s/step - loss: 0.0556 - accuracy: 0.9820
Epoch 6/10
1055/1055 [==============================] - 3900s 4s/step - loss: 0.0431 - accuracy: 0.9879
Epoch 7/10
1055/1055 [==============================] - 3901s 4s/step - loss: 0.0266 - accuracy: 0.9925
Epoch 8/10
1055/1055 [==============================] - 3888s 4s/step - loss: 0.0217 - accuracy: 0.9938
Epoch 9/10
1055/1055 [==============================] - 3898s 4s/step - loss: 0.0196 - accuracy: 0.9946
Epoch 10/10
1055/1055 [==============================] - 4305s 4s/step - loss: 0.0176 - accuracy: 0.9953
```

```
ModelLoss, ModelAccuracy = KerasModel.evaluate(X_test, y_test,batch_size=64)

print('Test Loss is {}'.format(ModelLoss))
print('Test Accuracy is {}'.format(ModelAccuracy ))
```

```
118/118 [==============================] - 230s 2s/step - loss: 0.0232 - accuracy: 0.9937
Test Loss is 0.023205148056149483
Test Accuracy is 0.9937333464622498
```

Fig. 5 The training results use the rice dataset with an Artificial Neural Network
**Source: Researcher Property**

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## DISCUSSIONS

Research Question 1, How to get a dataset for an experiment to make rice detection? An explanation of the dataset has been discussed in the previous section. The rice image dataset is done by downloading the dataset on the kaggle.com website. This website is a reference for researchers in the field of data science.

Research Question 2, What algorithm will be used in this research? This research chooses two appropriate algorithms for datasets that already have labeling. The method used is supervised learning, namely Artificial Neural Network and Convolutional Neural Network.

Research Question 3, How many algorithms will be compared? The algorithms used in this research are two algorithms. The Artficial Neural network algorithm and the Convolutional Neural Network Algorithm have been discussed in the methods section.

Research Question 4, How are the two algorithms different in terms of accuracy and training time? There are differences in terms of accuracy and in terms of the time required for training. It has been discussed in the previous section. In terms of good accuracy using the Convolutional Neural Network, around 99.3%. In terms of the time needed, according to the Artificial Neural Network algorithm, it takes about 10 minutes.

## CONCLUSION

The results of experiments on public datasets to build models with Artificial Neural Networks and Convolutional are different. Although the difference is not significant in terms of accuracy. The difference in these results can be compared between the two algorithms. The Artificial Neural Network algorithm works by entering by calculating the input layer, hidden layer and output layer. Output layer to make a classification method and can be used as a prediction of rice. In contrast to the Convolutional Network, where the input image is carried out by the convolution method into smaller vectors and flattened so that the image can be classified or predicted.

Achieving training time when using an Artificial Neural Network requires a relatively faster time, which is around 10 minutes. Meanwhile, training using a Convolutional Neural Network requires a longer time, which is 18 hours. For accuracy in training using Convolutional Neural Networks around 99.3%. While using the Artificial Neural Network algorithm it achieves an accuracy of around 98.2%.

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