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Recognition of Regional Traditional House in Indonesia Using Convolutional Neural Network (CNN) Method

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ABSTRACT

Indonesia is a country that has a lot of cultural diversity. This cultural diversity needs to be preserved. If this is not done, the culture that Indonesia owns can slowly disappear. The reduction in cultural values can also reduce the sense of belonging to the culture. This lack of sense of ownership makes it easy for other nations to make claims about the culture that Indonesia owns. Indonesia will lose its characteristics as a country with a lot of cultural diversity. One of the efforts to preserve culture is to recognize each culture's elements and the differences between one culture and another. For example, they realize traditional houses from various ethnic groups based on their image. In this research, the image classification of the characteristics of conventional houses from several ethnic groups in Indonesia was carried out. The type is used to identify an image. This study uses deep learning techniques with the Convolutional Neural Network (CNN) algorithm and Keras framework. This CNN uses several layers: convolutional, pooling, flatten, and dense. Developing deep learning models uses the Knowledge Discovery in Database (KDD) method. This method consists of nine stages. The built model is evaluated using k-fold cross validation with a k value of 5 and produces an average accuracy of 80%. This shows that the model built is capable of classifying well. The built model is evaluated with 3 different epoch values, namely 50, 75, and 100. The larger the epoch value used, the greater the accuracy value. The model building can also make predictions with an accuracy of 80%.

Keywords: CNN; KDD; Keras framework; k-fold cross validation; traditional house

INTRODUCTION

Indonesia is a country with a diverse culture. Culture is human knowledge that is used to understand the environment and guidelines for behaving as social beings (Abdulgani & Sati, 2019). Cultural diversity is also closely related to the variety of ethnic groups in Indonesia. The existence of similarities in culture, customs, and ancestors between one individual and another individual from an ethnic group. Based on the census conducted by the Central Statistics Agency (BPS) reported in 2016, there were a total of 1,340 ethnic groups or ethnic groups (BPS, 2015). Each ethnic group has different characteristics, such as the language used, traditional clothes, and also the shape of the traditional house (Prabowo et al., 2015)(Frederikh, 1998). Cultural diversity, including ethnic diversity, needs to be preserved because it is one of Indonesia's wealth (Nahak, 2019).

Globalization is an event that causes many changes in all aspects of people's lives. It can affect people's lives and mindsets. It can have a positive impact, but it can also have a negative effect. One example of the negative impact is the entry of foreign cultures. If not appropriately addressed, this foreign culture can fade into the local culture in Indonesia. Therefore, culture in Indonesia must be preserved in order to maintain its diversity. If this is not done, the culture that Indonesia owns can slowly disappear. The reduction in cultural values can also reduce the sense of belonging to the culture. This lack of understanding of ownership makes it easy for other nations to make claims about the culture that Indonesia owns. Indonesia will lose its characteristics as a country with a lot of cultural diversity (Siburian et al., 2021). One of the first efforts to preserve the culture is to recognize each culture's characteristics and identify the differences between one culture and another. For example, it acknowledges traditional houses from various ethnic groups based on their image. In this study, the image characteristics of conventional houses were classified from several ethnic groups in Indonesia. The classification is then used to identify an image.

Classification and image recognition of this traditional house can be done using deep learning techniques. Deep learning is a multi-layer algorithm used to extract features so that it can perform audio recognition, natural language processing, and also computer vision, including facial recognition (Farayola & Dureja, 2020). One of the deep

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learning methods that can be used for image classification is Convolutional Neural Network (CNN) which performs well in classifying image data sets as well as for real-time image recognition applications (Azis et al., 2020)(Chauhan & Ram, 2018)(Sunny et al., 2019). CNN has a better performance compared to other algorithms, namely Multi-Layer Perceptron (MLP)(Kohsasih et al., 2021). Convolutional is a part of a deep neural network which has been introduced to evaluate visual images. Convolutional is mainly implemented as a trained multi-layer network to perform classification decisions (Farayola & Dureja, 2020).

Research related to traditional houses was previously carried out by Abdulgani and Sati (2019), which was to introduce traditional Indonesian houses using Augmented Reality with the marker-based tracking method (Abdulgani & Sati, 2019). A similar study was also conducted by Silitonga, et al (2020), which was to introduce traditional houses of North Sumatra using augmented reality without markers (Silitonga et al., 2020). Recognition with Augmented Reality can only identify a traditional place according to a feature or menu that has been made; it cannot be used to recognize an image.

Aprianto (2021) conducted research related to CNN to detect brain tumours. This study also used threshold selection with histogram selection, resulting in an accuracy value of 75.42% (Aprianto, 2021). Biswas and Islam (2021) used CNN to classify handwritten automated digital. In this study, five different CNN architectures were implemented on two datasets. The accuracy values obtained are 99.53% and 98.93% for datasets 1 and 2. Compared to the Adam and RMSProp optimizers, decreasing the stochastic gradient with momentum produces the highest accuracy (Biswas & Islam, 2021). Another study was by Fauziah (2022) to identify paper images with an accuracy value of 0.98% (Fauziah, 2022). In addition, Radikto (2022) also uses CNN to classify vehicles on the highway, which produces an accuracy value of 98.18% on the sequential model and 99.64% on the VGG16 on the top model (Radikto et al., 2022). In this research, the recognition of traditional houses in Indonesia was carried out using the CNN method.

LITERATURE REVIEW

Deep Leaning

Deep learning is a machine learning concept that uses an artificial neural network. For many applications, deep learning models outperform shallow machine learning models and traditional data analysis approaches (Janiesch et al., 2021).

Deep learning involves algorithms that predict possible outcomes based on user data, which allow a computer to display behaviours learned from experiences rather than human interactions. It enables automation using algorithms to learn from data and make determinations and predictions. Every new information that the deep learning model receives makes it more intuitive (Muniasamy & Alasiry, 2020).

Deep learning includes four standard algorithms that allow the system to predict future results and detect patterns based on specific user data. The four algorithms are as follows:

Initially, the system starts with inputs and outputs provided to train the software. After that, the system can automatically generate outputs or targets for new data sets, which can be used from time to time. A supervised learning algorithm uses a sample set of past data and a new data set to predict the outcome.

An unsupervised learning algorithm does not involve any label or classification of data. The system evaluates the data to identify patterns and make predictions.

The semi-supervised learning algorithm combines unlabeled data and human-based training, where labelled online resources are provided to map specific inputs and outputs with higher accuracy.

The reinforcement learning algorithm includes tasks or goals the system must complete. Throughout the process, he receives feedback to learn the desired behaviour for the most effective approach through intuitive reinforcement signals (Muniasamy & Alasiry, 2020).

Deep Learning can be called differential programming. Deep learning has been used in various areas such as audio recognition, natural language processing, and computer vision, including facial recognition. Deep learning is a multi-layer algorithm used to extract features and identify edges such as letters, numbers, and faces (Farayola & Dureja, 2020).

Convolutional Neural Network (CNN)

Convolutional is part of a deep neural network that can be used to evaluate visual images. Convolutional is implemented as a multi-layer network trained to perform classification decisions. Approaches are built to perform different tasks simultaneously like feature extraction, data dimensionality reduction, and classification. In addition,

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convolutional is devoted to separating and detecting patterns in the input image (Farayola & Dureja, 2020). The CNN architecture consists of 2 parts: the feature extraction layer and the fully connected layer. The feature extraction layer consists of a convolutional layer and a pooling layer. It is at this fully connected layer that the deep learning process is carried out (Yuliani et al., 2019). An example of the CNN process flow can be seen in Figure 1.

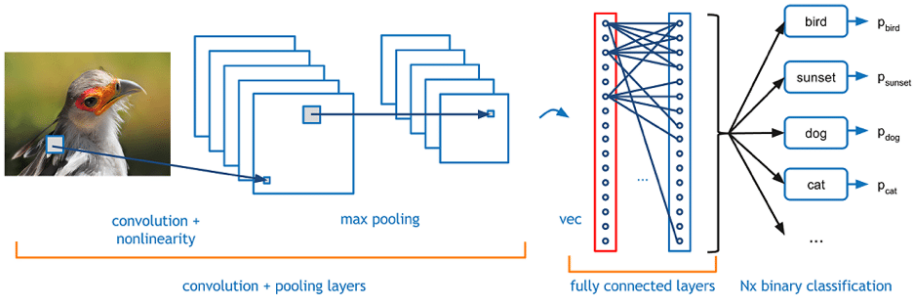

Fig. 1 CNN Process Flow

Convolutional Layer
This layer is the core of the CNN architecture. In this layer, the convoluted input image is filtered to extract features from the input image (Farayola & Dureja, 2020). Convolution will produce a linear transformation of the input image according to the spatial information in the data. The weights on the layer specify the convolution kernel to be used so that the convolution kernel can be trained based on the input (Pratiwi et al., 2021).

Pooling Layer
This layer is generally and periodically used to reduce the input data size to increase the network's computing speed. This process is performed independently on each feature map. Whenever a redundant image input situation arises, the pool layer portion will reduce the number of parameters. There are several types of pools, namely max pooling, average pooling, and some pooling. However, the most frequently used is max pooling. Max pooling can reduce the sample input data, reduce input dimensions and create room for assumptions about the sub-region in which the feature resides (Farayola & Dureja, 2020).

Fully Connected Layer
The fully connected layer is the layer that is used to perform transformations on the dimensions of the data so that the data can be classified linearly. To get the output from this layer, no convolution operation is needed but uses a multiplication computation matrix followed by an offset bias. With these operations, each neuron has a full connection to all activations in the previous layer, so this layer is called a fully connected layer (Alwanda et al., 2020).

ReLU Activation Function
ReLU is an activation function that is responsible for normalizing the value generated by the convolutional layer, for example, the rectifier activation function normalizes the value so that no value is below 0 using the max(0,x) function. If there is an input matrix then the value of ReLu is obtained in Equation (1).

$$f(x) = \max(0, x) \quad (1)$$

At the CNN backpropagation stage, the activation function derivative is used to obtain the input gradient value. Based on Equation (1), the derivative equation in Equation (2) is obtained (Yusuf et al., 2019).

$$f'(x) = \begin{cases} 1, & x > 0 \\ 0, & x \leq 0 \end{cases} \quad (2)$$

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SoftMax Activation Function

Softmax is an activation function used in the output layer. The output layer has many similarities with the fully-connected layer, what distinguishes the two layers is the use of the softmax activation function in the output layer and the ReLU activation function in the fully-connected layer. The softmax function equation is shown in Equation (3).

$$p_i = \frac{e^{x_i + \log(C)}}{\sum_{k=1}^{N} e^{x_k + \log(C)}} \quad (3)$$

In equation (3) is the value of neuron strength and log (C) is a constant value that can be determined, but in general the value set is max (x). The softmax activation function has the derivative of the function described in Equation (4) (Bendersky, 2016).

$$\frac{\partial p_i}{\partial x_i} = p_i(\delta_{ij} - p_j) \; dengan \; \delta_{ij} = \begin{cases} 1; \; jika \; i = j \\ 0; \; jika \; i \neq j \end{cases} \quad (4)$$

Cross Entropy Loss

Cross entropy loss is a function used to calculate the performance of a model, namely by calculating the error resulting from the model. The formula that used for cross entropy loss, which is in formula (5). Usually, this cross entropy loss is used after the softmax function (Pangestu et al., 2020).

$$H(p, q) = -\sum_{i=1}^{N} p_i \; log \; q_i \quad (5)$$

In the above formula the value of H is the distance, p is the value of the distribution (softmax), and q is the value of the label.

Adam

Adam is a method for efficient stochastic optimization that requires only first-order gradients with minimal memory requirements. The method calculates the individual adaptive learning rates for the different parameters of the gradient's first and second-moment estimates. The name Adam comes from adaptive moment estimation (Kingma & Ba, 2015).

K Fold Cross Validation

The data is divided into a collection of training sets and test sets in the evaluation process. The training set is used to train the model, and the test set tests the model. Then the performance evaluation of the model based on the error matrix is carried out to determine the model's accuracy. The method is less reliable because the accuracy obtained for one set of tests can be very different from that obtained for a different set of tests. K-fold Cross Validation solves this problem by dividing the data into multiple folds and ensuring that each fold is used as a test set at multiple CV points (Peryanto et al., 2020).

K-Fold Cross Validation is a given data set divided into several K sections/folds where each fold is used as a test set at some point. If the value of K is 5, then the data set is divided into 5 folds. In the first iteration, the first fold is used to test the model, and the rest is used to train the model. In the second iteration, the second fold is used as a test set while the rest functions as a training set. This process was repeated until each of the 5 folds had been used as a test set (Peryanto et al., 2020). An overview of 5-fold cross-validation can be seen in Figure 2.

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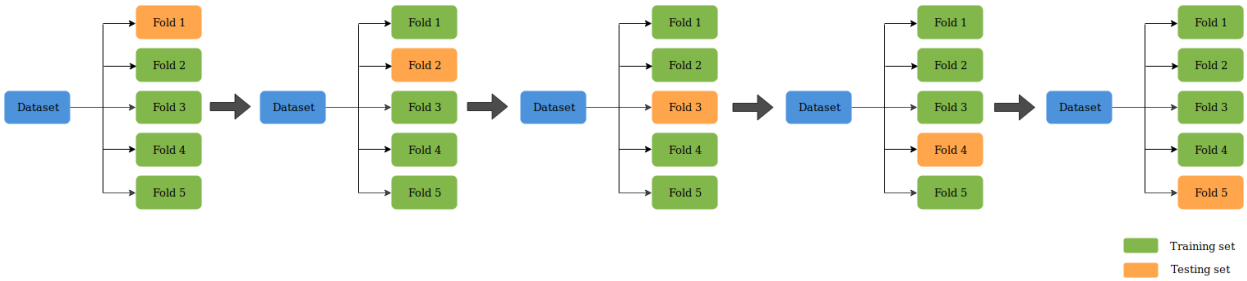

Fig. 2 5-Fold Cross Validation

METHOD

This research uses Knowledge Discovery in Database (KDD) method to classify traditional house images. KDD is an organized process to identify patterns from large and complex data sets. The design is valid and can be Knowledge Discovery in Databases (KDD) is the process of extracting previously unknown information and hidden patterns contained in the data (Gustientiedinaa et al., 2019). The results of the knowledge obtained can be used for a knowledge base that is used in making decisions (Safhi et al., 2019). KDD consists of nine steps, namely Domain understanding and KDD goals, Selection and addition, Preprocessing, Transformation, Data mining, Evaluation and interpretation, and Discovery knowledge. The stages of data mining are divided into three more stages, namely, Choosing the proper data mining model, Choosing the algorithm, and Using data mining methods (Rokach & Maimon, 2015). KDD stages can be seen in Figure 3. The following is an explanation of each stage:

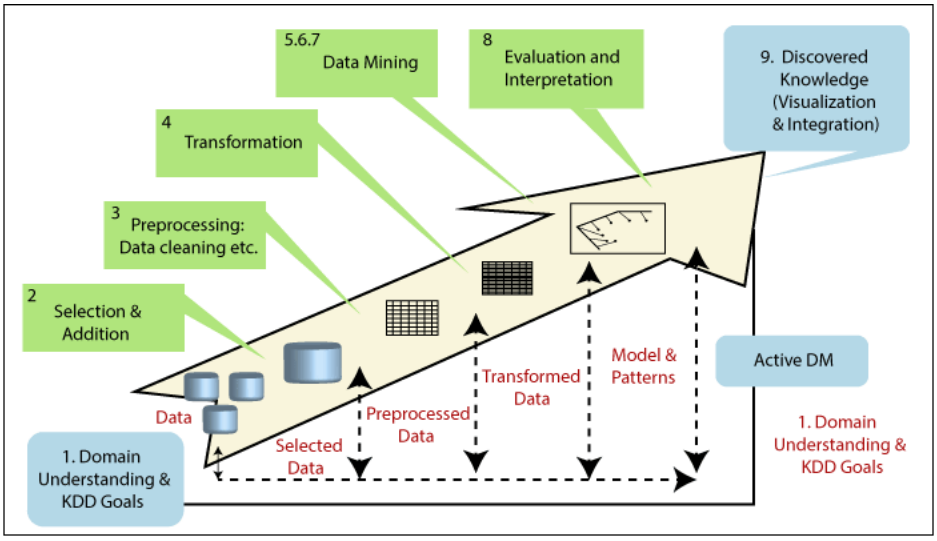

Fig. 3 KDD Process

Domain Understanding and KDD Goals

This step is an initial preparation that aims to understand what to do about transformations, algorithms, representations, and other things. Understanding and determining the goals of the end-user and the environment in which the knowledge discovery process will take place is carried out in this step.

Selection and Addition

In this step, all data is collected and integrated into one dataset, which is the basis for deep learning modelling. Data can come from documentation, the results of pulling data from the internet or using datasets already available on websites such as Kaggle.

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Preprocessing
The things that can be done are handling missing values and removing noise or outliers. In this step, data cleaning is carried out to improve data reliability. If there is no missing value, noise, or outliers, the process can continue to the next stage.

Transformation
The data is better prepared and developed at this stage to prepare for deep learning modelling. One method that can be done is image resizing and scaling.

Choosing the Proper Deep Learning Model
At this stage, selecting the Deep Learning model that suits the needs is conducted. The concept of deep learning consists of two main categories: first, multi-layer hidden neurons involve nonlinear processing and supervised or unsupervised learning techniques. The current layer takes the previous layer's output as input using a nonlinear processing algorithm on some of those layers. Learning techniques such as supervised or unsupervised are related to the target class label; their accessibility refers to the supervised system, while their absence refers to the unsupervised system. There are several types of neural networks and layers, such as Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNN), and Long Short-Term Memory (LSTM) (Siddiqui et al., 2019).

Choosing the Algorithm
In this step, the specific method used to search for patterns is carried out. Several algorithms that can be used for deep learning processes are Convolutional neural networks (CNN), Recurrent neural networks (RNN), Long short term memory networks (LSTM), and Self-organizing maps (SOM).

Using the Deep Learning Method
In this step, a deep learning algorithm is used to generate patterns. Algorithms are possible to be used repeatedly to obtain the results that match the needs. In this step, it is also possible to set the algorithm control parameters.

Evaluation and Interpretation
This step focuses on the completeness and usefulness of the induced model. This step involves evaluating and interpreting extracted patterns such as rules, reliability, and other things. In this step, the knowledge found is documented for further use.

Discovered Knowledge
In this step, the knowledge that has been found can be used and combined with other systems for further action. Knowledge becomes active in the sense that changes can be made to the system, and their effects can be measured. In fact, the success of this step determines the effectiveness of the entire process (Rokach & Maimon, 2015).

RESULT

This section describes the data mining modelling process according to the stages in the KDD method, starting from the data collection process to evaluating the resulting model. The following is an explanation of each stage that has been carried out in the KDD method:

Domain Understanding and KDD Goals
Based on the census conducted by the Central Statistics Agency (BPS) reported in 2016, there were 1,340 ethnic groups or ethnic groups. Each ethnic group has different characteristics, such as the language used, traditional clothes, and the shape of the conventional house. Cultural diversity, including ethnic diversity, needs to be preserved because it is one of Indonesia's wealth. One of the first efforts to keep the culture is to recognize each culture's characteristics and the differences between one culture and another. For example, they identify traditional houses from various ethnic groups based on their image. In this study, the image characteristics of traditional houses were classified from several ethnic groups in Indonesia. The classification is then used to identify an image.

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Selection and Addition

In this research, the dataset is a sample photo of a traditional house obtained from search results on the Google website. Each image obtained has dimensions of 275x183 pixels. There are three labels, the names of traditional places, which can be seen in Table 1.

Table 1
Description of Dataset

Traditional House Name	Label	Amount of Data
West Sumatra traditional house	Gadang	35
Yogyakarta traditional house	Joglo	35
West Kalimantan traditional house	Radakng	35

Preprocessing

In this research, data cleaning was not carried out because there were no missing values or outliers, so the research stage continued to the next stage, namely transformation.

Transformation

At this stage, the image is resized before being used for further data processing. The entire image is resized to a picture with a height of 75 and a width of 150 pixels. Figure 4. a is an image before resizing, while Figure 4. b is an image after resizing. Besides that, the image pixels are rescaled. The rescale process is multiplying each pixel in the image by a parameter value. If the parameter value is not specified or 0, then no rescaling will be performed. However, if the parameter is specified, then each pixel in the image will be multiplied by the value in that parameter. The rescale parameter value used in this study is 1/255.

(a) (b)

Fig. 4. Resizing the Image, (a) Image Before Resizing, (b) Image After Resizing

Each digital image is formed by pixels ranging from 0 to 255. A value of 0 represents black, and 255 is white. In colour images, there are three color maps, namely red, green, and blue with a value range of 0~255. The value of 255 is the maximum pixel value, so the rescale parameter value of 1/255 will transform the value from the range [0,255] to [0,1]. This can ease subsequent processes because the processed pixel values are smaller. The image of the transformation process can be seen in Figure 5.

Fig. 5. Image After Transformation

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Choosing the Proper Deep Learning Model
This research uses a supervised learning model to classify the dataset into the label given. The purpose of the deep learning model is for prediction.

Choosing the Algorithm
The algorithm used in this study is the Convolutional Neural Network (CNN) algorithm. Convolutional is implemented as a multi-layer network trained to perform classification decisions. Approaches like feature extraction, data dimensionality reduction, and classification are built to perform different tasks simultaneously. In addition, convolutional is devoted to separating and detecting patterns in the input image.

Using the Deep Learning Method
The model is built using the Keras framework. In the convolutional layer, filters with values of 16, 32, 64, and 128 are used. In addition, kernel size of 3x3, padding value of same, and use ReLU as activation function. There are several additional layers besides the convolutional layer used, namely the pooling layer with type MaxPooling2D, a flatten layer, a dense layer with 512 neurons in the hidden layer and ReLU, and a thick layer with 3 neurons hidden layer and softmax activation function. The summary of the model used can be seen in Figure 6.
The training process divides the dataset into two parts: training data and test data. To get the best data sharing, k-fold cross validation is used with a k value of 5. The data training process is carried out by using Adam as the optimization model, Cross entropy Loss as the loss calculation, and calculating the accuracy.

Layer (type)	Output Shape	Param #
conv2d_1112 (Conv2D)	(None, 100, 100, 16)	448
max_pooling2d_1111 (MaxPooling2D)	(None, 50, 50, 16)	0
conv2d_1113 (Conv2D)	(None, 50, 50, 32)	4640
max_pooling2d_1112 (MaxPooling2D)	(None, 25, 25, 32)	0
conv2d_1114 (Conv2D)	(None, 25, 25, 64)	18496
max_pooling2d_1113 (MaxPooling2D)	(None, 12, 12, 64)	0
conv2d_1115 (Conv2D)	(None, 12, 12, 128)	73856
max_pooling2d_1114 (MaxPooling2D)	(None, 6, 6, 128)	0
flatten_351 (Flatten)	(None, 4608)	0
dense_489 (Dense)	(None, 512)	2359808
dense_490 (Dense)	(None, 3)	1539

Fig. 6. Summary of the Model

Evaluation and Interpretation
At the evaluation stage, an analysis is carried out on how the k-fold and epoch values influence the model's accuracy. The effect of the k-fold on accuracy can be seen in Figure 7. In the figure, k with values 1 and 3 produce an accuracy of 50%, while k with values 2, 4, and 5 produce the accuracy of 100%. Based on this, an average accuracy of 80% is obtained. The accuracy value shows that the built deep learning model can classify images of traditional houses well.
The effect of epoch on accuracy can be seen in Table 2. In this research, an evaluation was carried out using three different epoch values, namely the epoch values of 50, 75, and 100. In the table, an epoch value of 50 produces an accuracy of 87.62%, an epoch value of 75 produces an accuracy of 95.24%, and an epoch value of 100 produces an

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accuracy of 97.14%. This shows that the greater the epoch value used, the better the accuracy obtained. Based on these results, the best epoch value used in this research was 100 epochs.

```
------------------------------------------------------------------------
Score per fold
------------------------------------------------------------------------
> Fold 1 - Loss: 1.0870801210403442 - Accuracy: 50.0%
------------------------------------------------------------------------
> Fold 2 - Loss: 1.0817292928695679 - Accuracy: 100.0%
------------------------------------------------------------------------
> Fold 3 - Loss: 1.1032798290252686 - Accuracy: 50.0%
------------------------------------------------------------------------
> Fold 4 - Loss: 1.0486499071121216 - Accuracy: 100.0%
------------------------------------------------------------------------
> Fold 5 - Loss: 1.0890021324157715 - Accuracy: 100.0%
------------------------------------------------------------------------
Average scores for all folds:
> Accuracy: 80.0 (+- 24.49489742783178)
> Loss: 1.0819482564926148
------------------------------------------------------------------------
```

Fig. 7. The Effect of K-fold on Accuracy

Table 2
The Effect of Epoch on Accuracy

Epoch	Accuracy
50	87.62%
75	95.24%
100	97.14%

How the value of each epoch affects the accuracy of the built deep learning model can be depicted in a graph. Figure 8 shows the effect of each epoch value on accuracy and loss value, with the epoch value used being 50 epochs. Figure 9 shows the impact of each epoch value on accuracy and loss value, with the epoch value used is 75 epochs. Figure 10 shows the effect of each epoch value on accuracy and loss value, with the epoch value used being 100 epochs. In each image, it can be seen that as the epoch value increases, the resulting accuracy increases. In addition, as the epoch value increases, the loss value decreases.

Fig. 8. Graph of Training Model Results with 50 Epochs

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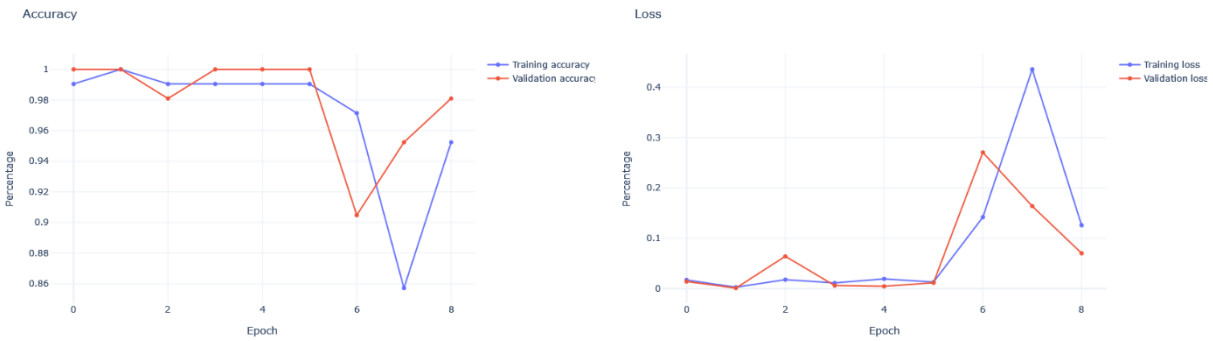

Fig. 9. Graph of Training Model Results with 75 Epochs

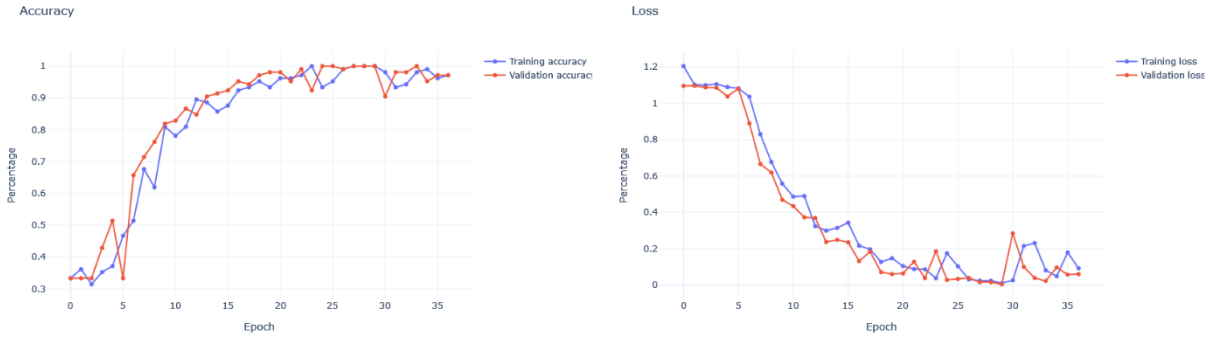

Fig. 10. Graph of Training Model Results with 100 Epochs

Based on the accuracy value obtained, both based on the k value in the k-fold and based on the epoch value used, it can be concluded that the CNN algorithm can be used to classify images of traditional houses.

Discovered Knowledge

In this stage, the deep learning model that has been built previously is used to predict the new data. There are 15 traditional house data which are divided into 3 classes, such as training and testing data, namely Gadang, Joglo, and Radakng. The model that has been built successfully predicts the new traditional house data with an accuracy value of 80%. The results of the accuracy can be seen in Figure 11.

```
1/1 [==============================] - 0s 10ms/step - loss: 1.2268 - accuracy: 0.8000
<keras.callbacks.History at 0x7f808ce15090>
```

Fig. 11. New Data Prediction Results

CONCLUSION

The artificial neural network model was created using the Convolutional Neural Network (CNN) algorithm and the Keras framework. The built model is evaluated using k-fold cross validation with a k value of 5 and produces an average accuracy of 80%. This shows that the model built is capable of classifying well. The built model is evaluated with 3 different epoch values, namely 50, 75, and 100. The larger the epoch value used, the greater the accuracy value. The model building is also able to make predictions with an accuracy of 80%.

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