

# Convolutional neural network (CNN) to determine the character of wayang kulit



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## ABSTRACT

Indonesia is a country with diverse cultures. One of which is *Wayang Kulit*, which has been recognized by UNESCO. *Wayang kulit* has a variety of names and personalities. However, most younger generations are not familiar with the characters of these shadow puppets. With today's rapid technological advancements, people could use this technology to detect objects using cameras. Convolutional Neural Network (CNN) is one method that can be used. CNN is a learning process included in the Deep Learning section and is used to find the best representation. The CNN is commonly used for object detection, would be used to classify good and evil characters. The data used consists of 100 black and white puppet images that were downloaded one at a time. The data was obtained through a training process that uses the CNN method and Google Colab to help speed up the training process. After that, a new model is created to test the puppet images. The result obtained a 92 percent accuracy rate, which means that CNN can differentiate the *Wayang Kulit* character.



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## 1. Introduction

*Wayang Kulit* is a traditional Indonesian art genre that has been designated as a "Masterpiece of Oral Intangible Heritage of Humanity" by UNESCO [1], [2]. *Wayang Kulit* has a variety of names and characters. *Wayang's* character demonstrates each character's personality, self-identity, image, character, and qualities [3], [4]. In general, it can be used as a symbol or example of an individual's character. *Wayang Kulit* characters can be divided into two categories: good (protagonist) and bad (antagonist). Most teenagers nowadays are not familiar with the *Wayang Kulit* characters. This is due to a decrease in teenagers' interest in traditional *Wayang* performances, lack of exposure to literature reading related to *Wayang Kulit*, and a lack of exposure of subject related to *Wayang* in schools. To spark the interest of the younger generation in *Wayang*, a range of possible solutions have been created, including establishing a *Wayang* puppeteer studio [5], craftsman center [6], [7], and performing *Wayang* on stage in various locations. Another worthwhile effort is producing *Wayang* in a more modern form such as *wayang hip hop* [8], comics [9], games [10], [11], and animations [12]–[14].

A technological breakthrough is needed to make the *Wayang Kulit* character more recognizable among the numerous existing solutions. A subset of artificial intelligence known as computer vision may be used as one potential approach. This branch investigates how a machine can identify an object while it is being observed. Convolutional Neural Network (CNN) is among the methods for detecting objects. Various studies on CNN, such as one conducted by [15] using CNN to detect faces using

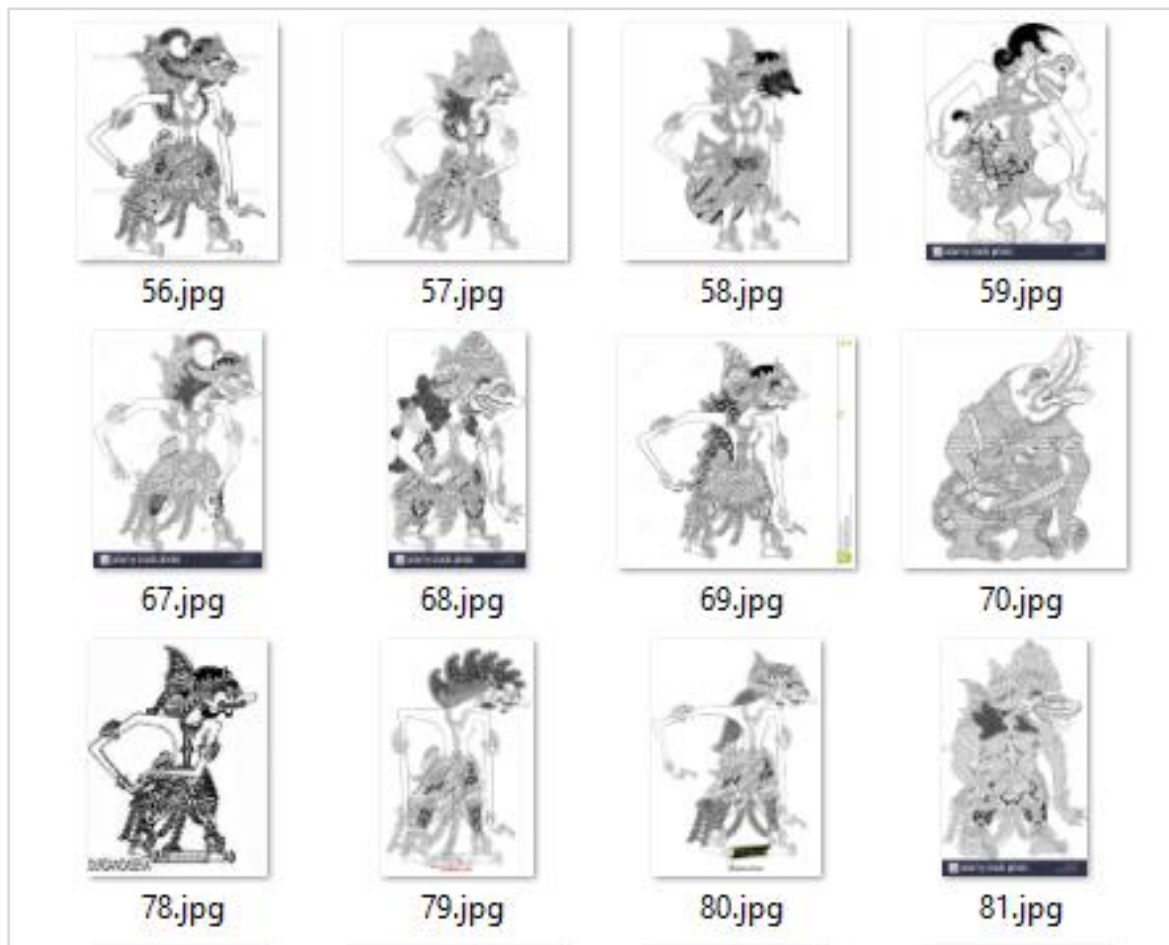
Tensorflow and Keras, provide a 95 percent accuracy rate. A similar research project achieved an accuracy of 98.14 percent. Another study has 98.3% of accuracy [16]. Furthermore, [17] recognize a face with a 92.5 percent accuracy rating. CNN appears to be accurate for facial recognition. Combination with other approaches such as SVM [18], GLCM [19] is also promising to improve the CNN performance. Inspired by the success of CNN for face recognition, this research will use CNN to classify the characters of *Wayang Kulit*. The findings of this research could be used as a starting point for another classification based on *Wayang Kulit* images.

## 2. Research Method

Black and white images of *Wayang Kulit* are used as data for this analysis. The *Wayang Kulit* images were acquired by downloading each shadow puppet one at a time from the Google image search engine using the image format Joint Photographic Group (JPG). Thus, a total of 100 images was download, which was then divided into two categories. There are 50 images classified as protagonists, and the rest were categorized as the antagonist. No identical images were classified in this data collection phase. In the data preprocessing stage, images were manually categorized by a *dalang* (puppeteer), assuming that a protagonist is facing left while the antagonist is facing right. The images were divided into train data and test data during this phase. Figure 1 shows the example protagonist *Wayang Kulit*, labeled with numbers 1 to 50. Figure 2 presents the example of an antagonist with numbers 51-100.



Fig. 1. Example of Protagonist Characters



**Fig. 2.** Example of Antagonist Characters

The scenarios are separated after the *Wayang Kulit* images have been categorized according to their characters. The purpose of the scenario distribution was to equally determine the CNN method's classification level in recognizing an image object, particularly a *Wayang Kulit* image. In this analysis, 50 shadow puppet pictures were divided into two groups of 25 images each. The protagonist, *Wayang Kulit* groups, were considered A1 and A2, whereas the antagonist *Wayang Kulit* groups were considered B1 and B2. Several preparations and assessment scenarios would be carried out as detailed in Table 1. The data of the 1<sup>st</sup> and 3<sup>rd</sup> scenarios is exactly the same, yet different in scanning the object. The first scenario scans the whole image while the 3<sup>rd</sup> only the head of *Wayang Kulit* image.

**Table 1.** Scenario Categorization

Scenario	Testing	Training
S1	A1B1	A2B2
S2	A2B2	A1B1
S3	A1B1	A2B2
S4	A2B2	A1B1

Figure 3 is a system architecture consisting of several stages: image for detection, neuron input, convolution + ReLu + pooling, fully connected layer, and classification. The first stage, image for detection, equates the image size (resize) with 640x640 pixels using RGB (Red, Green, Blue) with three kernel filters. The result is that the input neurons in the first layer are 1,228,800 neurons (640x640x3). Each neuron has a parameter with a value from 0 to 1.

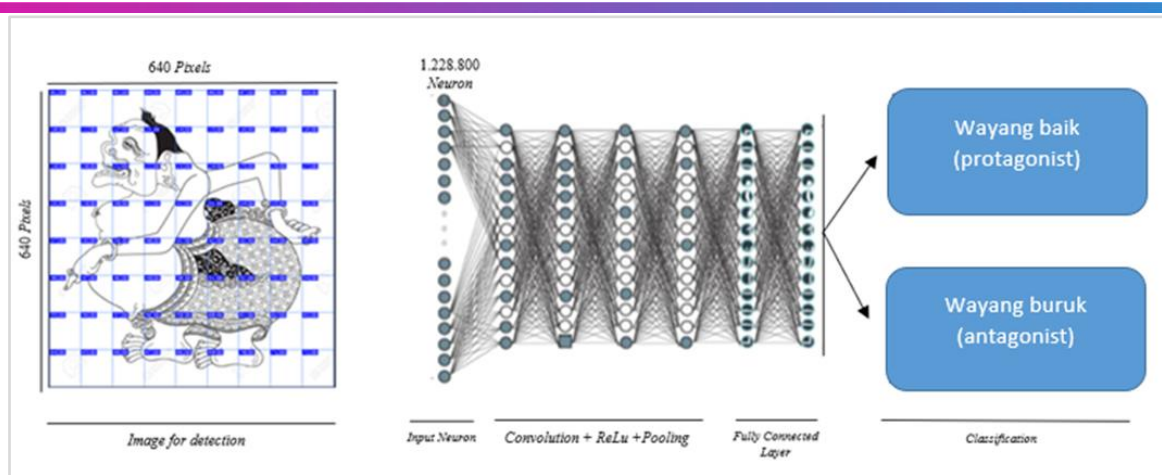


Fig. 3. Developed System Architecture

The next stage is the convolution process. The purpose of the convolution process is to extract the input image. The Convolution Layer comprises several neurons that form a filter in a matrix with length and height (pixels). There are two matrices in the filtering process, namely the input matrix and the kernel matrix. The input matrix value is obtained from the color level of each pixel. At the same time, the value of the kernel matrix is set according to the researcher's needs. The ReLu activation process coincides with the convolution process. ReLu activation aims to determine the output of convolution multiplication. The stage after the convolution and ReLu process is pooling. This pooling process aims to get a new, smaller matrix output. The pooling process carried out in this research is by multiplying the 5x5 matrix pooling layer with a 3x3 filter with stride 1, which produces max pooling with a 3x3 matrix size. These processes are often carried out to get the desired output matrix before proceeding to the fully connected layer process. The fully connected layer process connects all the results of the neurons in the previous process to the next layer of neurons so that images can be classified. The confusion matrix approach was used to test the classification results [20]. The Confusion Matrix is a table that demonstrates how effective an algorithm's output results are. For example, the character of *Wayang Kulit* is determined by image classification, which divides *Wayang Kulit* into two categories: protagonist and antagonist. Table 2 shows the confusion matrix, which is used for performance analysis.

Table 2. Confusion Matrix

Scenario			
Prediction			
Actual	Class	Protagonist	Antagonist
	Protagonist	TP	FN
	Antagonist	FP	TN

True Positive (TP) data is a correct classification based on positive information. True Negative (TN) data correct information based on negative information. False Positive (FP) generates less accurate classification results than positive data. False Negative (FN) is incorrectly classifying the data. These matrices are used to calculate the accuracy, precision, recall, and F-measure as in the following equations.

$$Accuracy = \frac{(TP+TN)}{(TP+TN+FP+FN)} \times 100\% \quad (1)$$

$$Precision = \frac{TP}{(TP+FP)} \times 100\% \quad (2)$$

$$Recall = \frac{TP}{(TP+FN)} \times 100\% \quad (3)$$

$$Fmeasure = \frac{2 \times (Precision \times Recall)}{(Precision + Recall)} \times 100\% \quad (4)$$

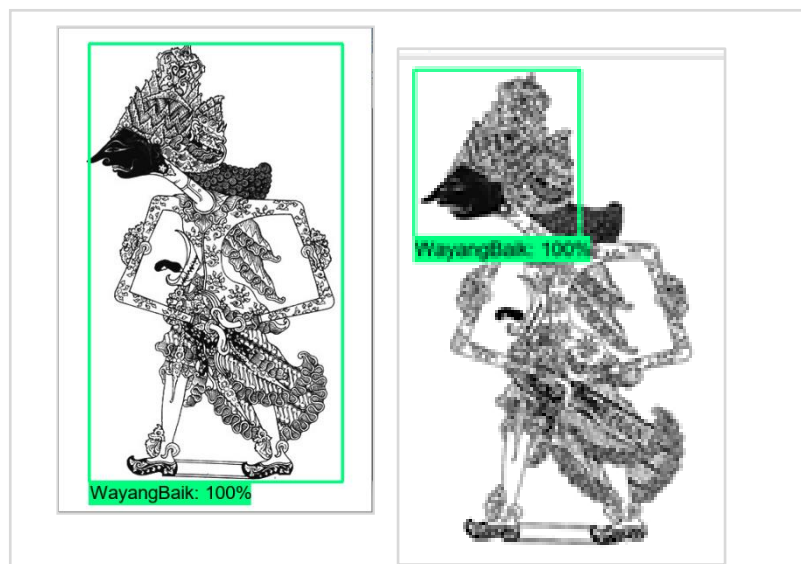
### 3. Results and Discussion

Table 3 shows the four scenarios of image classification results. We set the maximum value of iteration in all scenarios to 25000. The average loss value obtained in all cases was 0.523. Thus, a value of 700 sec is obtained for Scenario 1. Similarly, using Scenerio2, Scenario 3, and Scenario 4, a value of 800sec, 800sec, and 800sec respectively is obtained.

**Table 3.** Classification Detection Results

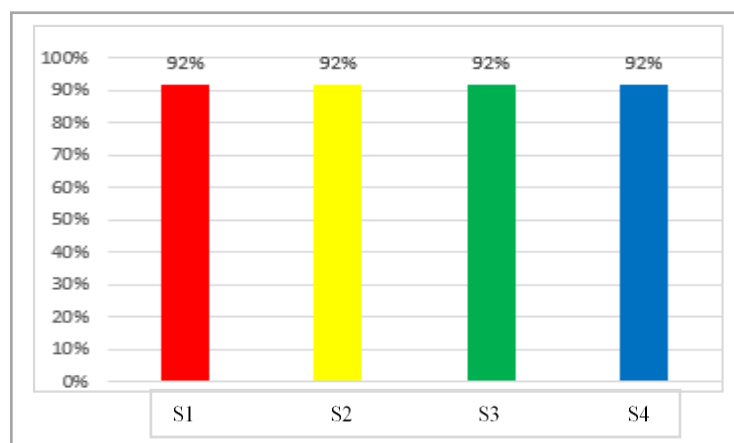
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Loss	0,52	0,519	0,526	0,528
Iteration	25000	25000	25000	25000
Time	700 sec	800 sec	800 sec	800 sec
Classification	99%	99%	100%	100%

Eventually, the overall rating for all cases receives a score of 99.5 percent. It means that CNN can differentiate protagonist (*Wayang Baik*) and antagonist (*Wayang Buruk*). Figure 4 shows the example of the image detection result. Both scenarios show that CNN recognizes the picture as 100% good character, even though the scanned part is different.



**Fig. 4.** Detection of Protagonist in Scenario 1 (left) and Scenario 3 (right)

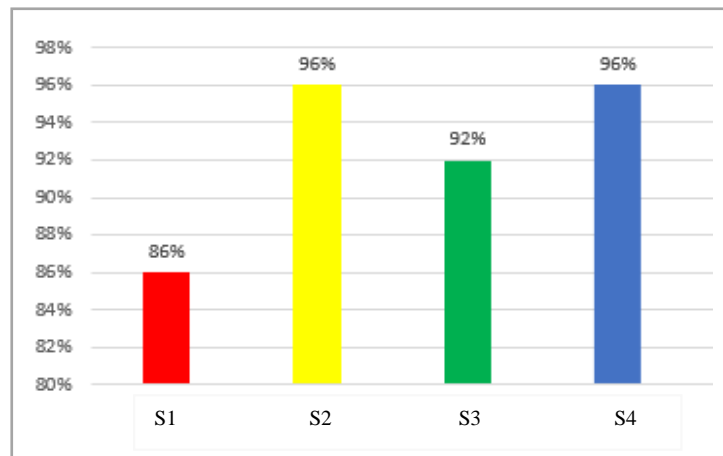
The CNN performance is measured using accuracy, precision, recall, and F-Measure results. Figure 5 shows the CNN accuracy. Red, yellow, green, and blue shows the order of scenario: S1, S2, S3, and S4.



**Fig. 5.** All Scenarios' Accuracy

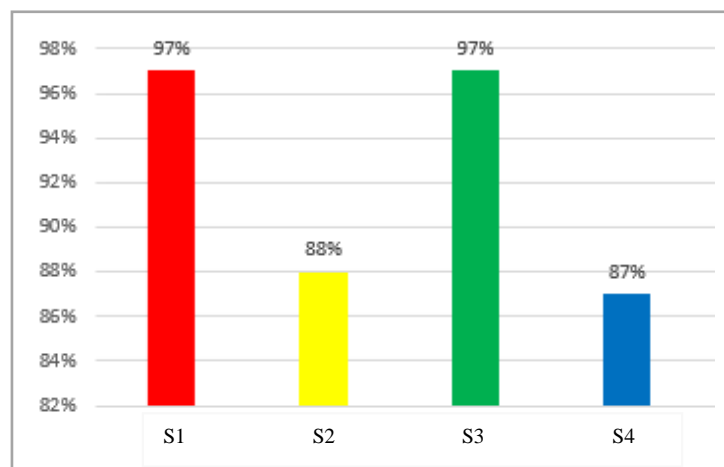


Figure 5 shows that all of the scenarios earned a 92 percent average score. This accuracy value is used to assess how accurate the classification results are when compared to the real values. However, there is no difference in accuracy between full image detection and head-only detection. Thus measuring with other indicators is needed for better justification.



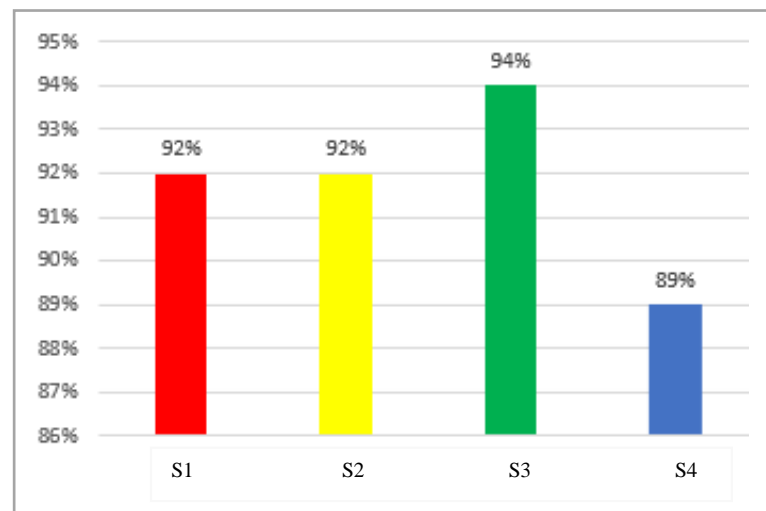
**Fig. 6.** All Scenarios' Precision

According to Figure 6, Scenario 2 and Scenario 4 offer precision values of 96 percent, 92, respectively. Scenario 3 has a precision value of 92 percent, and Scenario 1 has the lowest precision value of 86 percent. The average precision for the entire scenario was 92.5 percent. The precision value is used to assess the system's accuracy in predicting positive data as opposed to the overall positive forecast performance.



**Fig. 7.** All Scenarios' Recall

From Figure 7, it can be seen that the recall value in this analysis, the maximum value is obtained in scenarios 1 and 3 with a recall value of 97 percent, followed by Scenario 2 with an 88 percent recall value, and respectively Scenario 4 with an 87 percent recall value. The overall recall value was found to be 92.25 percent. The recall value is used to assess the system's degree of accuracy in predicting true positive data from overall data.



**Fig. 8.** All Scenarios' F-Measure

Accordingly, Figure 8 presents the maximum value is obtained in Scenario 3 with an F-Measure value of 94 percent, followed by Scenario 1 and Scenario 2 with an F-Measure value of 92 percent, and finally Scenario 4 with an F-Measure value of 88 percent, according to Figure 10, the results of the F-Measure value in this analysis. The average F-Measure value of 91.75 percent was obtained. The F-Measure value is calculated by multiplying the precision and recall values together.

#### 4. Conclusion

The system succeeded in classifying *Wayang Kulit* characters using the Convolutional Neural Network method with the output of protagonist and antagonist characters. In all scenarios, the level of accuracy for the classification of *Wayang Kulit* characters using the Convolutional Neural Network method obtained an average value of 92 percent. Precision was given an average score of 92.5 percent. The recall value was found to be 92.25 percent on average. The average value of the F-Measure value was 91.75 percent. In the future, we may increase the number and resolution of images that are more diverse to train the model and acquire a higher classification value. Another future classification is wayang's name instead of its character. This development may help teenagers to know their culture better.

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