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Recognition of Balinese Traditional Ornament Carving Images with Convolutional Neural Network and Discrete Wavelet Transform

Ni Luh Putu Kurniawati, Made Windu Antara Kesiman, I Made Gede Sunarya
Ganesha Education University, Sinagaraja – Bali, 81116, Indonesia

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ABSTRACT

Balinese carvings are less known to the public due to the lack of information about Balinese carvings. Minimum information about Balinese carvings can be overcome by utilizing advances in information technology in the field of image processing, namely the introduction of Balinese carving patterns. In the pattern recognition model of an image, several things can be analyzed, such as the recognition method used, feature extraction, including the model in preprocessing to reduce noise in a Balinese carving image. In this study, the Convolutional Neural Network (CNN) was used to classify Balinese carving images combined with Discrete Wavelet Transform (DWT) in extracting image features. The introduction was made to 25 categories of Balinese carving ornaments. Tests are generated based on the level of accuracy generated in the testing process. Analysis of the results was carried out on the resulting model, namely the analysis of the combination of CNN with DWT and without DWT. Testing the data set with 212 training data and 129 testing data using all DWT channels. Based on the results of the tests that have been carried out, it is found that using the DWT extraction feature produces a higher testing accuracy value, namely 35.66% for 25 classes and 74, 42% for 3 carving classes. Meanwhile, without using DWT, it produces an accuracy value of 32.56% for 25 classes and 66.67% for 3 carving classes. In future research, it is hoped that there will be an improvement in the data set and good shooting with a balanced and adequate number for the 25 carving classes that have been obtained. The contribution of this research is the analysis of the combination of CNN and DWT methods and the development of research datasets related to Balinese carving images.

Corresponding Author:

Ni Luh Putu Kurniawati, Ganesha Education University, Jalan Udayana No 11, Singaraja 81116, Indonesia
Email: luhputu101510@gmail.com

1. INTRODUCTION

Balinese carving is an implementation of imagination, aesthetic understanding, and the value of creativity towards natural characteristics by each artist [1]. In the book Gelebet (1981), it is stated that there are 34 classes/types of Balinese carving that have been successfully documented [2]. This Balinese carving class has many motifs or types in its application to traditional architecture and buildings in Bali, but along with its development, many people do not know or understand the types of Balinese carvings [3]. Balinese carvings are less known to the public due to the lack of information about Balinese carvings. Minimal information about Balinese carvings can be overcome by utilizing advances in information technology in the field of image processing, namely the introduction of Balinese carving patterns.

Several studies related to the recognition of carving patterns have been carried out by Sumantara (2017) [3] and Putra (2019) [4]. Sumantara (2017) built a Balinese carving recognition application using the Oriented FAST and Rotated BRIEF (ORB) method which is able to recognize Balinese carving images based on the key points feature. The results of the accuracy of the research on the Balinese carving recognition process with the ORB method reached a percentage of 48% recognized as correct. Previous studie performs Balinese carving recognition using edge detection and Multilayer Perceptron [5]. Research shows that the resulting accuracy is 43%. The research that has been done shows that an analysis of the Balinese carving recognition model is still needed. So in this study, the Balinese carving recognition model was analyzed in order to increase the accuracy of the resulting recognition.

In the pattern recognition model of an image, there are several things that can be analyzed such as the recognition method used, feature extraction, including the model in preprocessing to reduce noise in an image [4]. To recognize patterns in an image, there are several recognition methods that can be used, such as K-Nearest Neighbors (KNN), Support Vector Machine (SVM) [6] [7], and Convolutional Neural Network (CNN) [8] [9]. The results of the comparison of the three methods have been carried out in the classification of weather images which show that CNN has the best performance with an accuracy of 0.942, precision of 0.943, recall of 0.942, and F1 Score of 0.942 [10]. So in this study, CNN was used to classify the image of Balinese carvings.

Based on Putra's research (2021), in the future, it is necessary to combine classification methods with feature extraction methods to improve classification accuracy. One of the feature extraction methods that can be used in performing image feature extraction is Discrete Wavelet Transform (DWT) [11]. Wavelet Transform in image processing is usually used to extract features because it can perform vector space decomposition in a set of nested vector spaces with different resolutions so that it is possible to analyze functions in both the time and frequency domains [12] [13]. The results showed that the best decomposition level for feature extraction with this method was at level 3 with a feature vector length of 24 and with an accuracy rate of up to 97.1% in the case study of vehicle number plate recognition [14]. The combination of these methods in the recognition also shows that the resulting accuracy increases [15]. The introduction with the addition of the DWT and SVM methods resulted in a classification accuracy rate reaching 92% compared to SVM alone which only reached 84%.

Based on the studies that have been described, this study will introduce the image of Balinese carvings. CNN method is used in image recognition [16], which is combined with the DWT feature extraction method. The final result of this study is expected to produce a recognition model with increased accuracy from previous studies.

2. METHODS

In general, users will input engraving image data for further processing in the recognition model. The developed model recognizes the inputted Balinese carving image. The stage to do the introduction is divided into 2, namely the training and introduction stages.

2.1. Data Collection

Fig. 1 is a category diagram of Balinese carvings obtained from Gelebet's book (1981) and research conducted by Kesiman (2022) [17]. In Fig. 1 there are 34 categories of Balinese carvings that will be used in the initial data collection. Based on the analysis carried out with the experts as shown in Appendix 3, it can be seen that there are differences in the interpretation of the existing carvings. Appendix 3 shows that 9 categories have different interpretations by experts. Therefore, in this study, 25 categories will be used that do not have different interpretations. In this study, the image data that have been obtained are interpreted and verified by 3 practitioners, namely: Mr. I Komang Subrata, S.Pd, M.Pd, a carving art teacher at SMKN 2 Sukawati, Mr. I Nyoman Karyana, S.Pd, a carving art teacher at SMKN 1 Sukawati, and Mr. I Made Suyatna, S.Sn a cultural arts teacher at SMK PGRI 2 Badung. Table 1 show the examples of data for 25 categories of carvings that have been collected and labeled by experts.

2.2. Training

The training stage is carried out starting from the input image, grayscale, feature extraction with DWT [18][19] can be seen in the Fig. 2, and the training process with CNN for the formation of the featuring model [20]. Image data that has been carried out is then processed into a grayscale image. The image resulting from the initial processing will then be extracted for its features [21]. At this stage, the Discrete Wavelet Transform is used to obtain features by reducing the image dimensions from high dimensions to low dimensions [22]. So at this stage four sub-images will be obtained [23] [24], namely: approximation (cA), horizontal high frequency

(cH), vertical high frequency (cV), and diagonal high frequency (cD). After feature extraction is complete, the energy value and standard deviation are used as features in each image. The results of this feature extraction are then used at the training stage using CNN. The final results of this stage will be produced featuring the training data model used in the introduction stage.

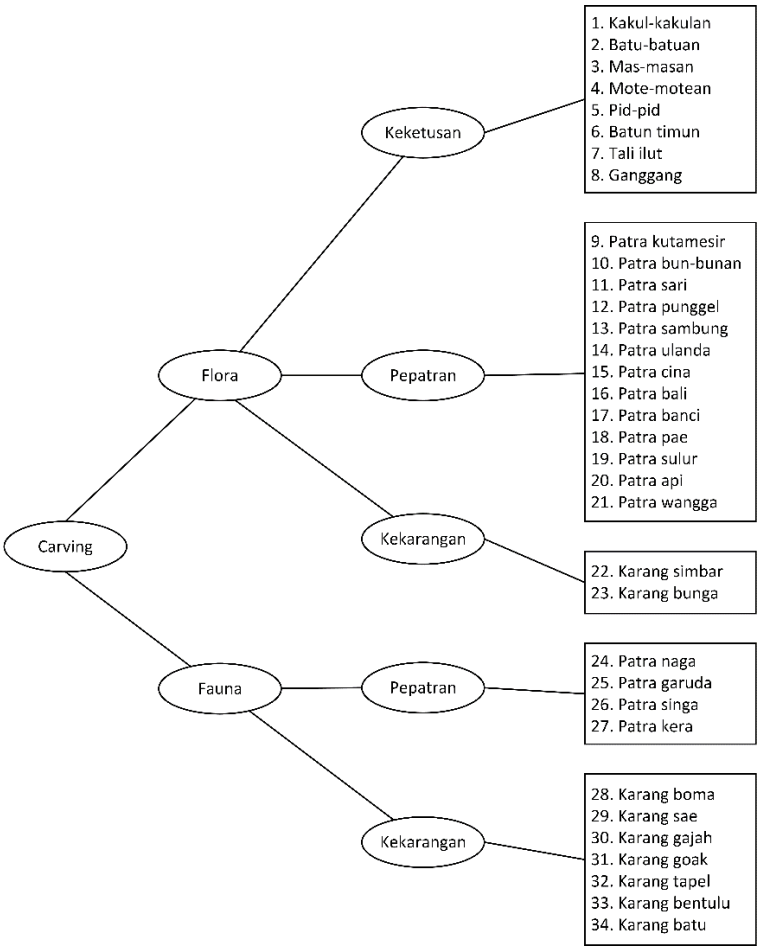
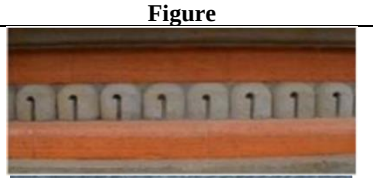


Fig. 1. Categories of Balinese Carvings

Table 1. Research Data Design

No.	Name Carved	Figure
1.	Batu-batuan	
2.	Kakulan	
3.	Mas-masan	

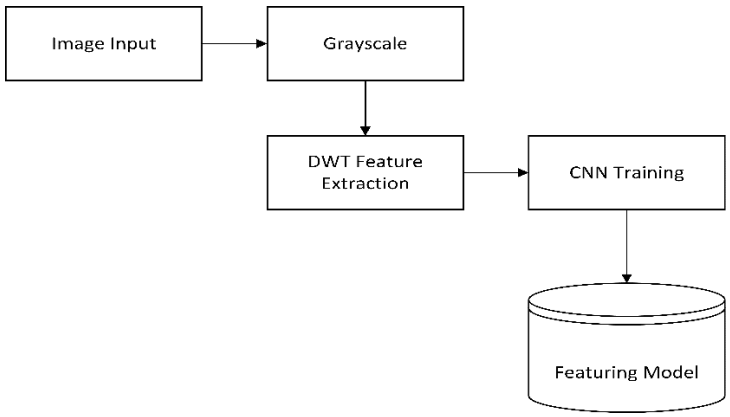


Fig. 2. Training Phase

2.3. Introduction Stage The introduction

At this stage, the introduction of the test image that has been prepared will be carried out. The training phase is carried out starting from the input image, grayscale, feature extraction with DWT [25], and the classification process with CNN to recognize the test image. For the stages themselves are illustrated in Fig. 3.

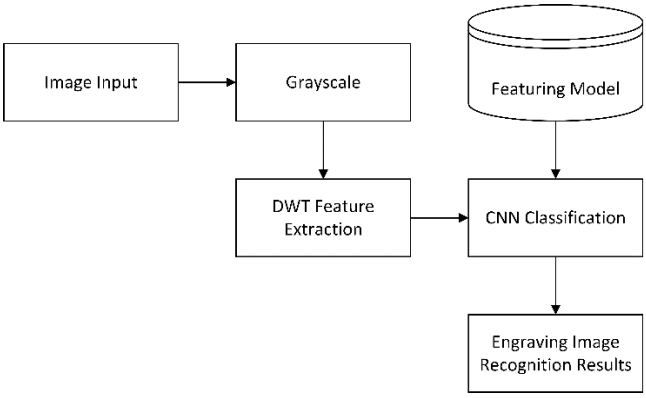


Fig. 3. Recognition Stage

The image used at this stage is a Balinese carving image according to the categories described in Fig. 1. In the initial data processing, the image will be changed from RGB to grayscale. Furthermore, the feature extraction process is the same as in the training stage [26]. The last stage in character recognition is the classification stage using CNN according to the feature model generated at the training stage [9]. The output of this stage will produce classification results from the test image of Balinese carvings.

2.4. Analysis of Results

Analysis of the results was carried out on the resulting model, where an analysis was carried out between the combination of CNN with DWT and without DWT. The results of the recognition of each test data are then tested to see the level of effectiveness of image recognition of the Balinese carving test that has been determined.

3. RESULTS AND DISCUSSION

In this section, the results of the research are explained and, at the same time given a comprehensive discussion. Results can be presented in figures, graphs, tables, and others that make the reader to understand easily, as shown in the Fig. 4. The discussion can be made in several sub-chapters. It is strongly suggested that comparisons with results from other published articles are provided to give more context and strengthen the claim of novelty.

From the results of the training process to get a model that has been stored, this model is then used in the testing process. The testing process is carried out by entering the address of the test data folder on Google

Drive as much as 129 data. After getting a 4-dimensional array from the DWT process, then the feature learning process is carried out where the parameter and state values are obtained in the training process. The learning feature process at the testing stage used is the same as the learning feature process at the training stage but does not update the parameter values and state features. The test is carried out on the value of the accuracy level of the testing process. The results of the testing process are in the form of the accuracy level of the prediction results from each test data, which is carried out wherein, the accuracy rate value is 35.66%.

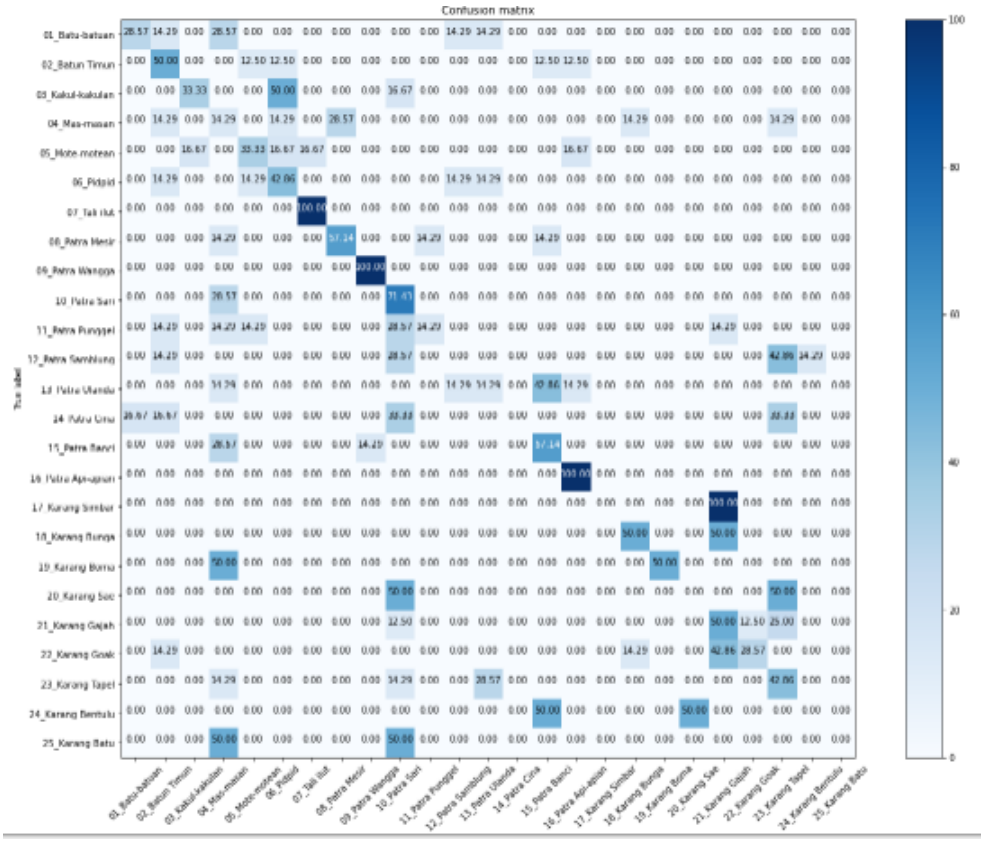


Fig. 4. Confusion Matrix CNN + DWT Results

In the CNN test without DWT, the layer used is almost the same as in the previous experiment, except that the module does not display DWT train data. The result of the training process is 100% legible. While the test image succeeded in obtaining 32.56% accuracy which was declared correct. Then it is poured into the confusion matrix which displays the answer data with the accuracy of predicting the correctness of the data according to the training data image shown in the Fig. 5. Based on the two experiments, the comparison can be described in the form of the Table 2.

The test results show that the experimental results using the DWT extraction feature have a higher testing accuracy value, namely, 35.66%. Testing the data set with 212 training data and 129 testing data using all DWT channels. To prove that DWT helps improve testing accuracy, the researchers also conducted additional experiments by reducing the number of carving classes from 25 to 3 major classes, namely *Keketusan*, *Pepatraan*, and *Karangan*, while still using the previous training and testing data formation, namely 212 for training data and 129 for data testing, it looks like Fig. 6. The types of Balinese carvings above are experimentally tested in each of the major categories, namely succinctness, *Pepatraan*, and coral. The results obtained are shown in Table 3.

Table 2. Test Results Against the Traditional Balinese Carved Ornament Data Set

Test	Amount of training data	Amount of testing data	DWT	Batch Size	Epoch	Training	Testing Results
CNN+DWT	212	129	4 channel	10	25	100 %	35.66%
CNN	212	129	-	10	25	100 %	32.56%

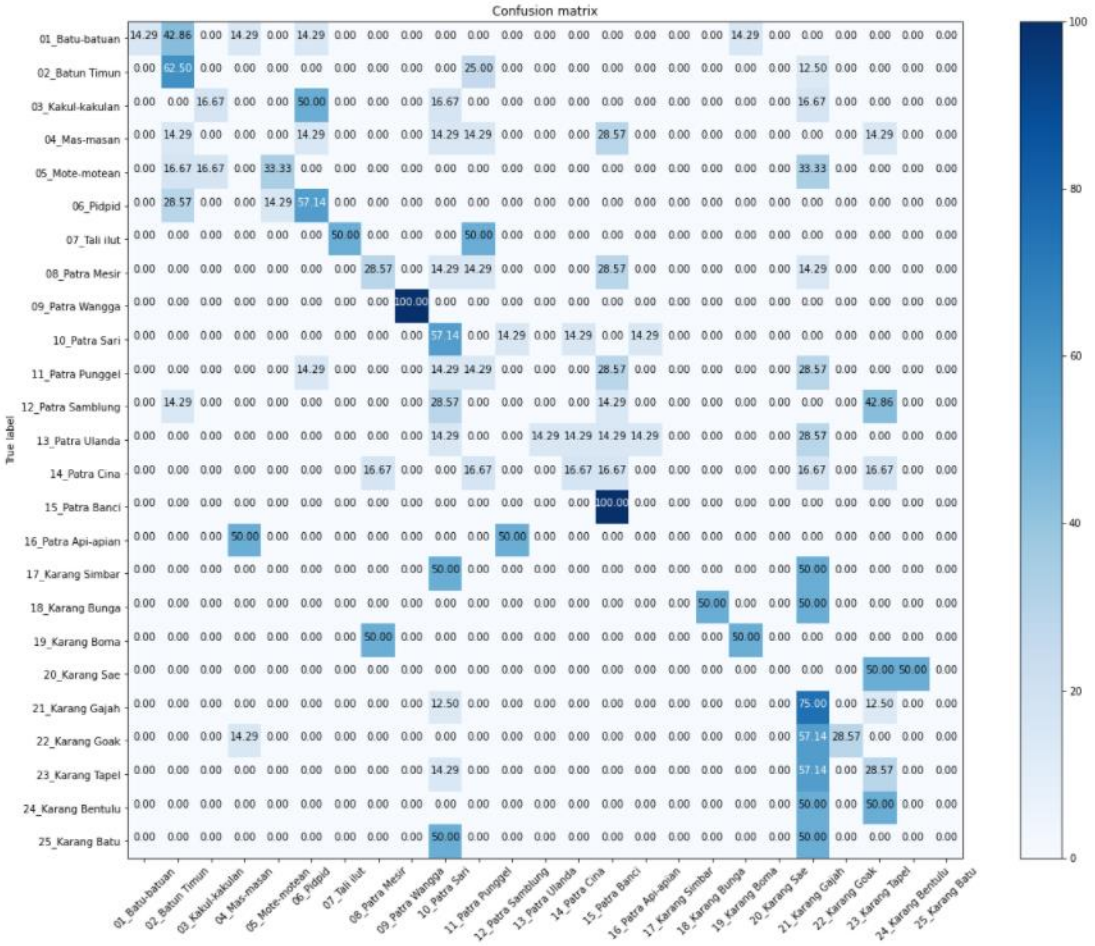


Fig. 5. Confusion Matrix CNN

Category	Total of Sample Data	
	Training	Testing
01_Keketusan	74	43
02_Pepatraan	79	52
03_Kekarangan	59	34
Total Data	212	129

Fig. 6. Data Set Training and Testing

Table 3. Test Results Category Carving

Parameter Test	Category Carving Experiment with DWT				Without DWT
	Keketan	***Pepatraan***	***Karangan***	**Total**	**Combine Combined**
Data Set Training	74	79	59	212	212
Training Results	%	100 %	93.22 %	97.64 %	100 %
Total Data Set Testing	43	52	34	129	129
Testing Results	44.19 %	48.08 %	29.41 %	74.42 %	66.67 %

The tests were carried out in each category with test parameters of epoch 25 and mini-batch 10 with a test value of 44.19 for Ruthlessness, 48.08% for *Pepatraan*, 29.41 % for Corruptness, 74.42% for the combination of the three categories, and 66.67% for the combination of the three categories without using DWT.

4. CONCLUSION

Based on the research that has been done, it can be concluded several things that answer the problem formulation that has been defined, namely the introduction of Balinese carving images using the CNN and DWT methods by combining the two methods in the feature extraction and introduction process. In general, at the training stage, using DWT there is a discrete wavelet transform image conversion stage followed by initialization of CNN parameters and calculation of feature learning in Balinese carving image recognition. Testing the data set with 212 training data and 129 testing data using all DWT channels. Based on the results of the tests that have been carried out, it is found that using the DWT extraction feature produces a higher testing accuracy value, namely 35.66% for 25 classes and 74, 42% for 3 carving classes. Meanwhile, without using DWT, it produces an accuracy value of 32.56% for 25 classes and 66.67% for 3 carving classes.

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BIOGRAPHY OF AUTHORS

Luh Putu Kurniawati is a master's degree student at Universitas Pendidikan Ganesha, Singaraja, Bali. She is a graduate of STMIK Denpasar, majoring in Informatics Engineering. Now she is working as a teacher in a Senior High School. E-mail: luhputu101510@gmail.com

Made Windu Antara Kesiman is a senior lecturer at Ganesha University of Education, Singaraja, Bali. He is a Doctor of Computer Science from Universite De la Rochelle, French. Windu specializes in Digital Image Processing, Algorithms and Data Structure, Algorithm Analysis Design. E-mail: antara.kesiman@undiksha.ac.id

I Made Gede Sunarya, is a senior lecturer at Ganesha University of Education, Singaraja, Bali. He is a Doctor of Electrical Engineering from Sepuluh Nopember Institute of Technology, Surabaya. Sunarya is specialized in Digital Image processing. Email: sunarya@undiksha.ac.id