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Smart Mobile Application for Detecting Balinese Masks to Introduce Balinese Culture to World Tourism

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Keywords

Mask recognition, Balinese masks, Deep Learning, Cultural Tourism, VGG 16

Abstract. Indonesia, known for its remarkable cultural diversity, encompasses many ethnic groups, each preserving its distinct cultural heritage. Among Indonesia's cultural treasures is the ancient art of traditional mask-making, referred to as "topeng." Bali, in particular, stands out as a hub for topeng artistry, with roots tracing back to prehistoric eras, serving as a profound representation of Bali's rich cultural values. Bali showcases a broad spectrum of traditional dances incorporating masks as props. The use of shows in these performances often piques the curiosity of residents and tourists, prompting questions about the symbolism and cultural context surrounding their use. People recognize the physical appearance of masks but need to gain knowledge of their names and deeper cultural meanings. The inherent similarities among mask forms further confound both locals and foreign visitors in distinguishing between various types of Balinese masks. This research endeavors to tackle this issue by developing an Artificial Intelligence (AI) system that is integrated into a mobile application using the CNN (VGG-16) method. The primary objective is to introduce and promote the captivating Balinese mask culture and artistry, bolstering cultural tourism through cutting-edge mobile technology. The anticipated outcomes include a nationally accredited journal publication, a user-friendly mobile application, and the acquisition of intellectual property rights. This research constitutes a transition from Technology Readiness Level (TRL) 2 to TRL 3, wherein the AI framework will be rigorously validated, incorporating accuracy, precision, recall, and F1-score assessments, all seamlessly integrated within the mobile system.

1. INTRODUCTION

Balinese mask dances have existed since the reign of King Jaya Pangus, namely around the 10th century. This is stated in a collection of Jaya Pangus inscriptions, which say that performances used face coverings, aka masks [1]. The existence of these masks also represents the cultural values of Bali itself, both historical, cultural, and religious meaning. Of the many types of Balinese masks that exist, most people only know the shape or appearance, not the name, type, or meaning of each Balinese mask [2]. There are various kinds of traditional Balinese dances, some of which use masks. Not only dance, but some theater performances use masks instead of wearing makeup [3]. Of course, during the performance, there will be questions from local and foreign people regarding the meaning of wearing the mask. The lack of local and foreign communities' knowledge regarding each Balinese mask can result in the fading of Balinese mask art culture. The use of technology is a suitable medium to use in preserving Balinese culture, as outlined in this mask art. Not just preserving regional arts, providing information related to Balinese masks through technology can introduce the art, history, meaning, and so on of Balinese masks to the public. So, a Balinese mask preservation system is needed to preserve Balinese masks in the digital era like now. Through innovative mobile technology using mask screen capture techniques using a cellphone camera, users will be given detailed information about the mask. In this research, one of the Deep Learning methods that is effectively used in the case above is the Convolutional Neural Network (CNN). The use of CNN is because this method will try to imitate the human visual image recognition system so that it can detect objects with unpredictable positions thanks to the convolution process [4]. The expected result of this research is that the public and tourists can be helped in recognizing and learning information about Balinese masks and help introduce Balinese culture to world tourism.

The proposed research is based on several preliminary studies. Until now, several methods have been used to study Computer Vision, both in the form of face recognition and even performing image classification. Another study using the CNN method is "Convolutional Neural Networks for Real-Time Face Recognition." In this study, the use of the CNN method was able to detect faces in dim lighting, so the superiority of the CNN method is unquestionable [5]. Other studies also use CNN to help classify wayang character objects based on digital imagery. In this study, the level of accuracy obtained during the training process compared to the testing process is greater. So that the model's performance can be considered optimal in classifying wayang images [6], another research on food recognition is "A Deep Learning based Food Recognition System for Lifelog Images." In this study, food classification was carried out using a deep-learning approach. Based on this research, the use of the CNN method succeeded in classifying the food inputted by the user [7]. Based on previous research, researchers use CNN as the core of the mask recognition process to carry out mask recognition. Because based on previous research, the CNN method can classify images with accuracy above the SVM method. In other cases, namely facial recognition in real-time, this method can recognize faces with low lighting. This is one of the advantages of the CNN method compared to other methods. The updates the authors carried out in this study resulted from introducing masks using CNN, which the authors will use to help preserve Balinese mask culture. In essence, this application will recognize the mask that appears on the camera and provide information from the mask.

2. METHODS

System Workflow

Development of a system capable of recognizing mask images and displaying detailed information about the mask. As shown in Figure 1, the mask image recognition stage begins with the user taking a screen capture of the mask using a mobile phone camera, which then sends the resulting image to the cloud system. In the cloud system, the mask image will be classified to get the final result regarding mask information that matches and is close to the image.

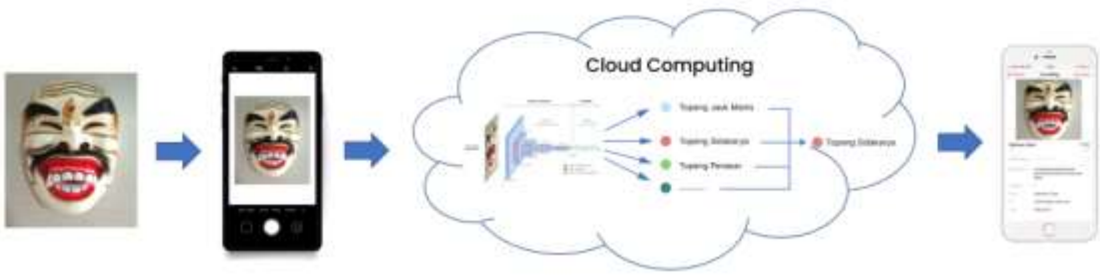

Figure 1. System Workflow

Algorithm workflow

CNN

The Convolutional Neural Network (CNN) workflow starts by taking image data as input, which is then processed through convolution layers to extract hierarchical features from the image [8]. Each convolution layer uses filters to recognize specific patterns and components. The convolution results are activated using non-linear functions such as ReLU to introduce non-linear aspects to the model. The pooling layer is used to reduce the dimensions of the feature map. After several layers of convolution and pooling, the feature map is converted into a one-dimensional vector, which is then processed through fully connected layers for classification or regression [9]. The CNN model is trained by adjusting its parameters using an optimization algorithm to minimize a loss function that measures how the model predictions approach the actual values in the training data. Once training is complete, the model is tested on independent test data to measure its performance and general ability in a task such as object recognition in images.

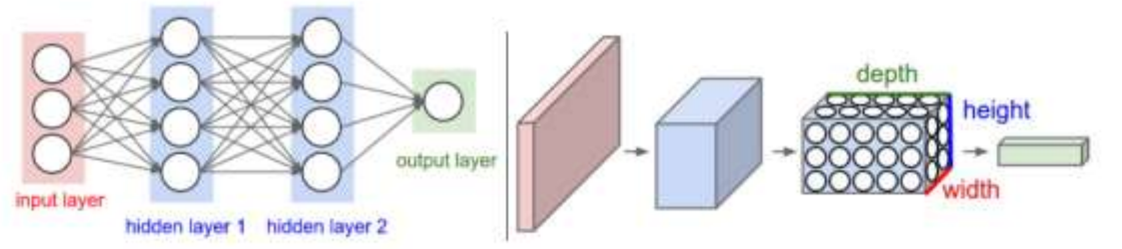

Figure 2. CNN Algorithm Workflow

VGG 16

The VGG-16 workflow is an artificial neural network architecture consisting of 16 convolution and fully connected layers [10]. It starts by taking an image as input. It uses a series of convolution layers with small filters (3x3) followed by a ReLU activation layer to extract features in an increasingly higher hierarchy. Then, subsampling uses a max-pooling layer to reduce feature dimensions. After several convolution and max-pooling layers, the components are adjusted into a one-dimensional vector and composed through several fully connected layers. Finally, the output layer performs classification using the softmax activation function [11]. VGG-16 is renowned for its great depth and ability to perform object recognition accurately in various image processing tasks.

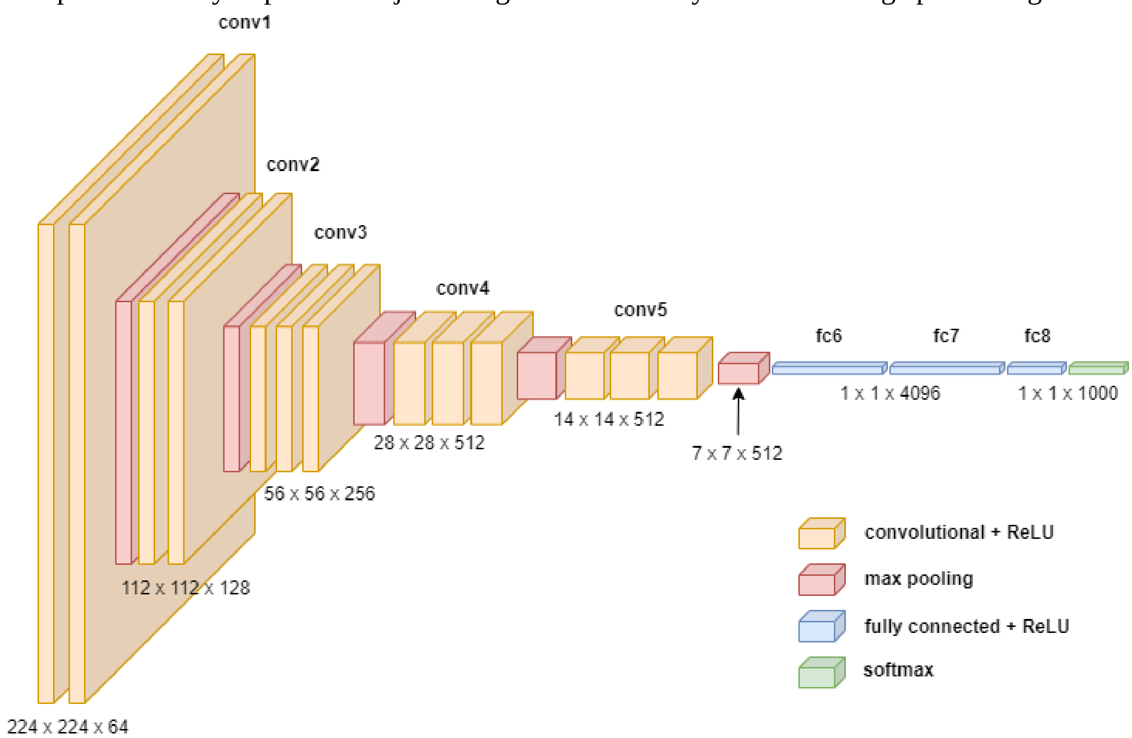

Figure 3. VGG 16 Algorithm Workflow

Alexnet

The AlexNet workflow is a revolutionary artificial neural network architecture in image processing, consisting of 5 convolution layers followed by fully connected layers[12]. It starts by taking an image as input and running it through convolution and ReLU activation layers to extract low-level to high-level features. Then, a max-pooling layer is used to reduce the feature dimensions. After convolution, the components are organized into a one-dimensional vector and processed through fully connected layers that define the final classification [13]. AlexNet introduced techniques such as dropout to reduce overfitting and GPUs to speed up training, enabling highly accurate object recognition and becoming one of the critical milestones in developing deep learning in image processing.

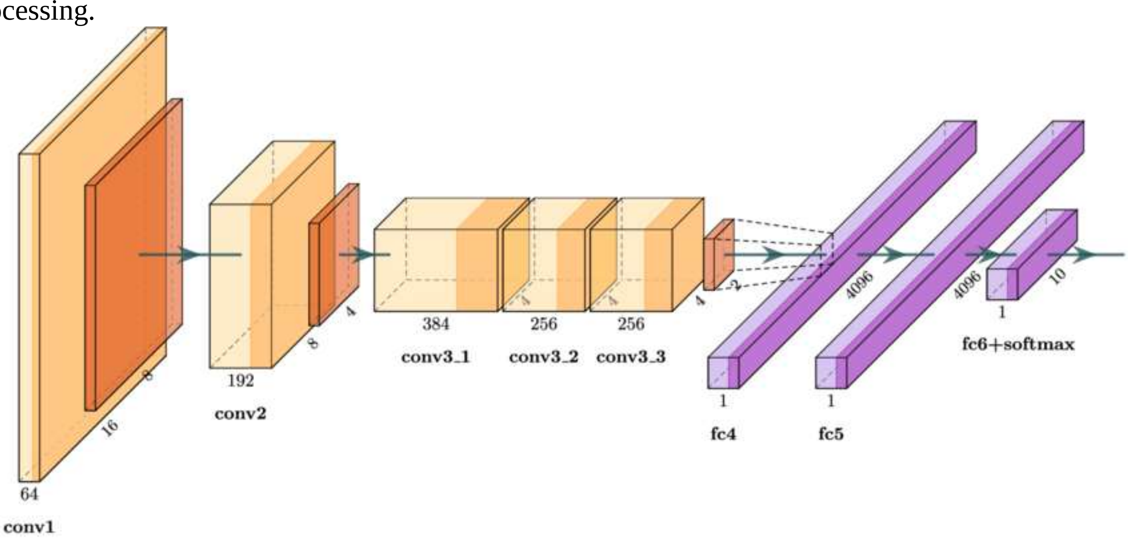

Figure 4. Alexnet Algorithm Workflow

Datasets

This research was carried out by collecting data through a literature study and observing research objects [14]. The observations carried out were attending and taking pictures of typical Balinese masks found in the Balinese mask museum in Gianyar. The observation results obtained were seven types of shows, where every kind of mask had 50 mask images that would be trained to make models—literature study, literature taken from the internet, and books that can support research. The author found several studies from the literature study that encouraged the theme of detecting Balinese masks to promote Balinese culture to world tourists.

Figure 5. Datasets

System Testing

System testing is a process to check whether the software produced can be run according to standards [15]. This study will conduct the accuracy, precision, recall and F1-score tests. Accuracy is the percentage of total data that is correctly identified. Accuracy is calculated by dividing the number of correct data by the total and test data [16]. The accuracy calculation formula is as follows:

$$Akurasi = \frac{true\ positive + true\ negative}{true\ positive + true\ negative + false\ positive + false\ negative}\ x\ 100\% \quad (1)$$

Precision compares the amount of relevant data found to the amount found. Precision calculations are carried out by dividing the amount of correct data with a positive value by the number of correct data with a positive value and incorrect data with a positive value [17]. The precision calculation formula is as follows:

$$Presisi = \frac{true\ positif}{true\ positif + false\ positif} \quad (2)$$

Recall compares the amount of relevant material found against the relevant material. The recall calculation is done by dividing correct data with a positive value by the sum of the correct data, which has a positive value and wrong data, which has a negative value [18]. The precision calculation formula is as follows:

$$Recall = \frac{true\ positif}{true\ positif + false\ negatif} \quad (3)$$

F1-Score is a comparison of the weighted average of precision and recall. The best value of the F1-Score is 1.0, and the worst is 0. Representationally, if the F1-Score has a good score, it indicates that our classification model has good precision and recall [19]. The F1-score calculation formula is as follows:

$$F1 - Score = 2 \times \frac{Recall \times Precission}{Recall + Precission} \quad (4)$$

3. RESULTS AND DISCUSSION

User Interface

User Interface is the appearance of a product that bridges the system with the user, where the UI display can be in the form of attractive colours, shapes and writing on the mobile application [20]. The following is the initial interface design of the application to be developed. In this system, the front end is developed using the Dart programming language and the back end is developed using Python. Based on Figure 6 below, a button is used to scan the mask you want to know about. On the interface, there is a history of detections that have been carried out before and a number of the number of detections that were carried out on the previous date.

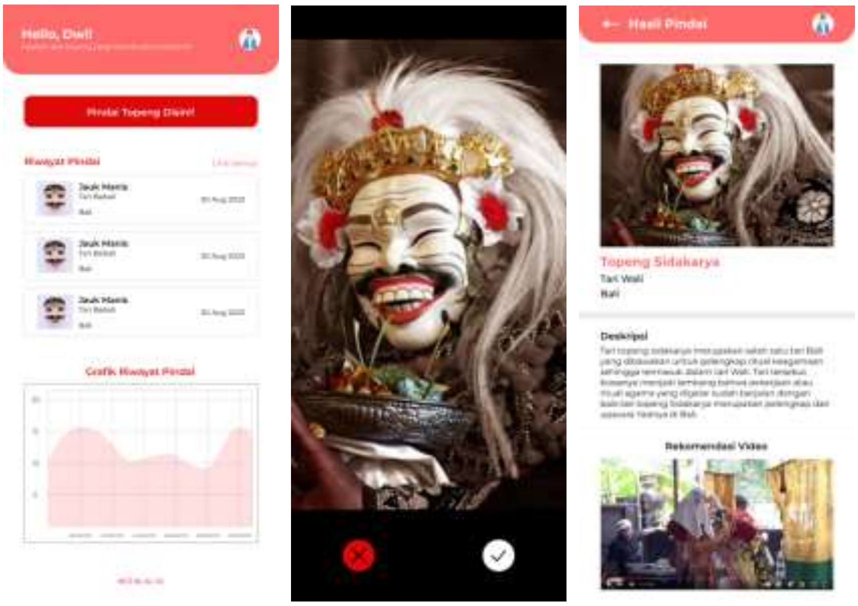

Figure 6. Interface Main

Implementation Mobile Apps with Model AI

After carrying out the training data process and getting a model from the training process, the next step is to test the model using test data. Based on the illustration in Figure 14, the system is still in the first design stage and can recognize masks detected by the user. In its implementation, the masks the user detects will be saved, which aims to increase the detection accuracy of artificial intelligence. In the future, active learning will be added to the system so that the implemented artificial intelligence will learn the stored mask data automatically.

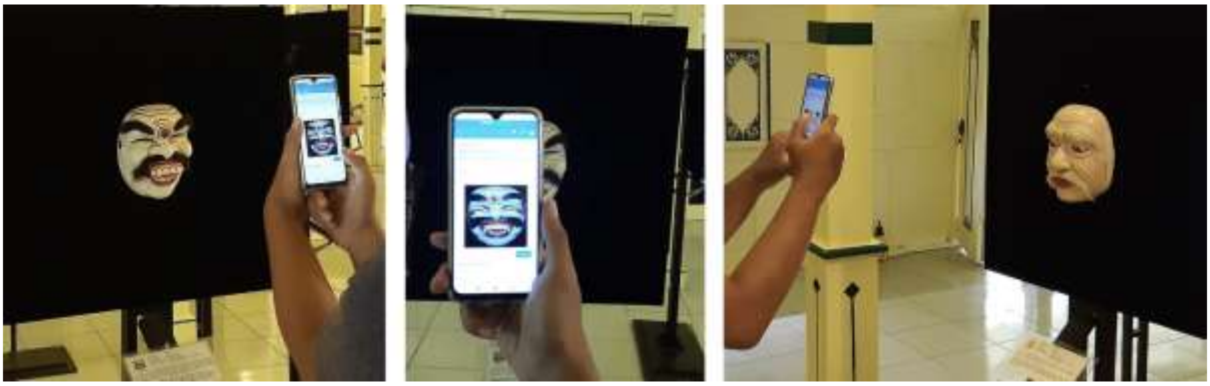

Figure 7. Model Integration with Mobile Applications

System Testing Results

System testing determines whether the system built can function properly and according to plan. This mask detection system is tested directly by comparing manual observations with observations from the system. The following are the results of system testing that has been carried out.

Table 1. Testing Each Method

System Test ID	Manual Observation	CNN	VGG 16	Alexnet
1	Topeng Bujuh	False	True	True
2	Topeng Dalem	True	True	True
3	Topeng Sidakarya	True	True	True
4	Topeng Keras	True	True	False
5	Topeng Dalem	True	True	True

6	Topeng Tua	True	False	True
7	Topeng Wijil	False	True	False
8	Topeng Wijil	True	True	True
9	Topeng Penasar	True	True	True
10	Topeng Dalem	False	True	False
11	Topeng Tua	True	True	True
12	Topeng Keras	True	True	True
13	Topeng Sidakarya	True	True	True
14	Topeng Tua	True	True	False
15	Topeng Penasar	True	True	True
16	Topeng Bujuh	True	False	True
17	Topeng Penasar	True	True	False
18	Topeng Tua	False	True	False
19	Topeng Sidakarya	False	True	True
20	Topeng Dalem	True	False	True
Percentage of correct detection		75%	85%	70%

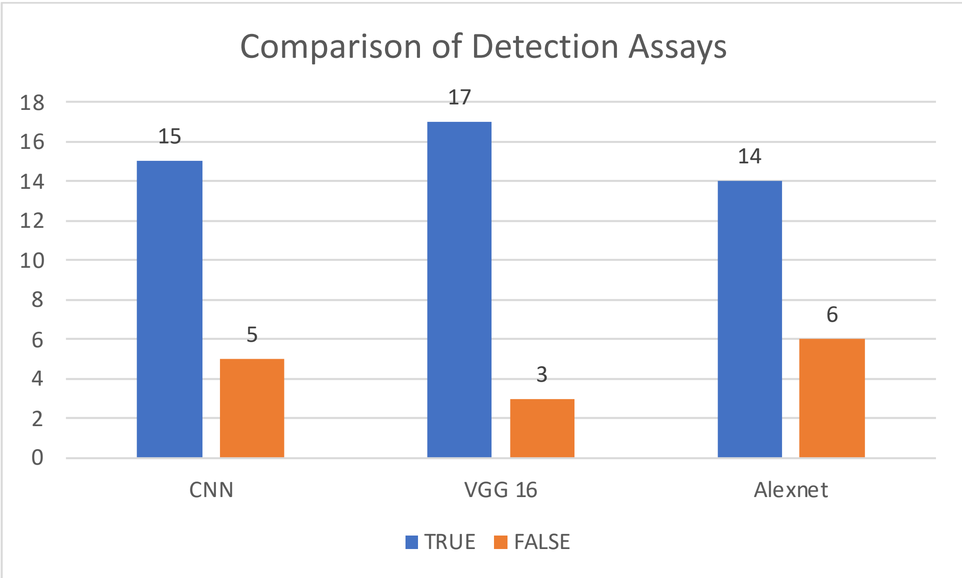

Figure 8. Test Results of Each Method

Based on the tests carried out 20 times on each model, the result is that the VGG 16 method has the highest success rate between the CNN and Alexnet methods, where VGG 16 has an 85% success rate in detecting masks while CNN only has a 75% success rate. And Alexnet with a success rate of 70%.

This research aims to compare the methods used to detect objects. There are several stages before you can compare these methods, including collecting a dataset that will be used as a research object, carrying out training on the dataset with the method that will be used, implementing the model obtained from the training results in a mobile application, and finally testing the each of these models. The results of the tests that have been carried out will get different results when the dataset used changes.

4. CONCLUSION

Based on the description described previously, the conclusions that the authors draw from research regarding Smart Mobile Applications for Detecting Balinese Masks to Introduce Balinese Culture to World Tourism include the research methodology applied in this study being able to detect masks as expected. Of the 20 experiments on each method, a comparison resulted in the CNN method getting an accuracy of 75%, the VGG 16 method getting an accuracy of 85%, and the Alexnet method getting an accuracy of 70%. This study proves that object detection using the VGG 16 method gives better results than the CNN and Alexnet methods.

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