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IMAGE CLASSIFICATION RECOGNITION OF GAMELAN MUSICAL INSTRUMENT TYPES USING CNN METHOD ANDROID BASED

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Abstract: In the ever-evolving digital age, the use of digital images has become a significant and widespread phenomenon in various fields. Digital image processing and understanding has become an important requirement in various applications, including pattern recognition and computer vision. On the other hand, the sustainability and understanding of cultural treasures, such as Gamelan, is becoming increasingly crucial. UNESCO has recognized Gamelan as Indonesia's 12th World Intangible Cultural Heritage, reminding us of the responsibility to maintain and preserve this cultural heritage. In the digital era, where interest in traditional musical instruments is declining, Convolutional Neural Network (CNN) is implemented as a solution to classify Gamelan musical instrument types based on visual patterns in images. CNN, implemented in an Android system, showed good results with accuracy reaching 98% in the model test stage and 79% in the Android application test. The classification model using TensorFlow Lite, specifically MobilNetV2, was able to recognize Gamelan musical instrument types in the training dataset. However, it should be noted that this model is limited to that dataset. This research contributes to the merging of technology and cultural heritage, enabling the use of technology to enhance cultural understanding and sustainability.

Keywords: Gamelan, CNN, image classification, cultural heritage, MobilnetV2

1. INTRODUCTION

In today's digital era, the use of digital images has become increasingly widespread and significant. Advocacy of digital technology, better internet connectivity, and increased use of social media have resulted in rapid growth in the use and exchange of digital images. Digital images are used in various industries and fields, including photography, graphic design, pattern recognition, computer vision, medical science, data analysis, security, and entertainment (Yuadi, 2023). In everyday life, the use of digital images is also found in various applications such as social networks, photo sharing platforms, and online communication (Sugiharto, 2018). Therefore, understanding and processing digital images has become a very important need in the current era.

Based on information revealed by the Minister of Education, Culture, Research and Technology (Mendikbudristek) Nadiem Anwar Makarim in a press release on 15 December 2021 (Ministry of Culture, P, 2021), gamelan was officially recognized by UNESCO as an Intangible Cultural Heritage (WBTB) 12th World from Indonesia (Hanin, 2023). This recognition not only caught the world's attention, but also gave the Indonesian people a big responsibility in protecting and preserving this cultural wealth. Based on arts and culture data from Wonosobo district (Tourism and Culture Department, 2023), there are 1030 communities of arts and culture

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activists. Meanwhile, there are 992 communities that have gamelan musical instruments with a total of 21,533 members, while the population of Wonosobo based on (Central Statistics Agency (BPS), 2022) is 896,346 Wonosobo residents. It can be concluded that the percentage of people interested in Javanese Gamelan art is 2.4%.

So because of these problems, a solution is needed to create application media by utilizing appropriate technology such as Convolutional Neural Network (CNN) to improve cultural preservation by overcoming people's difficulties in easily distinguishing and recognizing the visual characteristics of each gamelan musical instrument.

2. METHOD

Data collection is a stage for searching and obtaining data, data used in the process of creating an application system for recognizing types of gamelan musical instruments using the Android-based Convolutional Neural Network method through 3 data collection techniques, namely Library and Literature Study, Internet Searching, Observation. Literature research is carried out by looking for references from books, journals and articles that are relevant to the problems to be researched, with the aim of finding solutions to these problems. Internet searching is a data collection technique through online search engines that provides access to various information from various periods. This makes it easier for researchers to find data quickly, completely, and available from various years. Observation is a data collection technique that refers to an approach where the author takes datasets or objects directly to support research and development of image classification models for gamelan musical instruments.

The sample used in this research is image data of gamelan musical instruments totaling 14 classes, including bonang, xylophone, gender, gong, kempul, kendang, kenong, rebab, saron, and flute. The total image used was 700 characters consisting of 50 images for each gamelan musical instrument and divided into two parts, namely 80% train data and 20% testing data. Here are the details:

Table 1. Research population and sample

Sample	Amount of Training data	Amount of Test data
Bonang	40 Character	10 Character
Demug saron	40 Character	10 Character
Gambang	40 Character	10 Character
Gender	40 Character	10 Character
Gong	40 Character	10 Character
Kempul	40 Character	10 Character
Kendang	40 Character	10 Character
Kenong	40 Character	10 Character
Kethuk Kempyang	40 Character	10 Character
rebab	40 Character	10 Character
Saron Barung	40 Character	10 Character
Saron Penerus (Peking)	40 Character	10 Character
slenthem	40 Character	10 Character
suling	40 Character	10 Character
Kethuk Kempyang	40 Character	10 Character
rebab	40 Character	10 Character
Saron Barung	40 Character	10 Character
Saron Penerus (Peking)	40 Character	10 Character
slenthem	40 Character	10 Character
suling	40 Character	10 Character
Total	560 Character	140 Character
Total of data	700 Character	

The variables in this research are displayed in Table 2. Regarding the operational explanation and definition of research:

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Table 2. Variables and Definitions of Research Variables

Variable	Definition of Research Variables
bonang	The image is a bonang character
Demug Saron	The image is a demug saron character
gambang	The image is a xylophone character
gender	The image is a gender character
gong	The image is a gong character
kempul	The image is a kempul character
kendang	The image is a drum character
kenong	The image is a kenong character
Kethuk Kempyang	The image is of the kethuk kempyang character
rebab	The image is a fiddle character
Saron Barung	The image is in the form of a saron barung character
Saron Penerus (Peking)	Image in the form of the character of the successor saron (peking)
slenthem	The image is a slenthem character
suling	The image is a flute character

In this research, the author used the waterfall method approach to develop the system. The waterfall method is a systematic and sequential approach to software development (Pricillia, 2021).

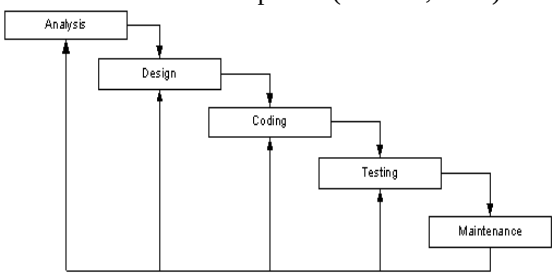

Fig. 1. Flow of the Waterfall Method

In the classification process, a design and implementation process is carried out which consists of several stages. Here are the details:

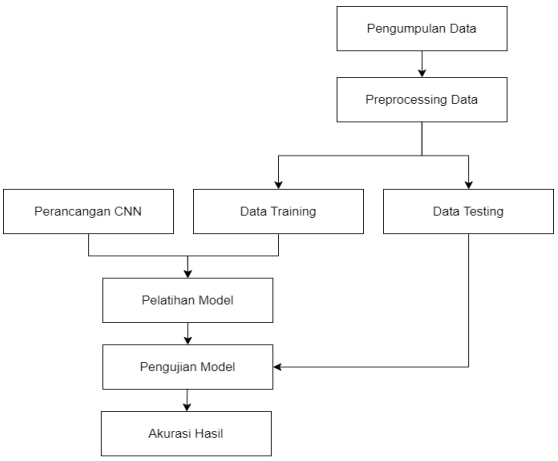

Fig. 2. CNN Method Classification Stages

The following is an explanation of the stages of classification of gamelan musical instruments using the CNN method (Putra, 2016)

1. Data Collection

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In the data collection process that will be used in each class of image data used, there are 14 types of gamelan musical instrument classes. These include bonang, Demug Saron, gambang, gender, gong, kempul, kendang, kenong, Kethuk Kempyang, rebab, Saron Barung, Saron Penerus (Peking), slenthem and flute. The image is in JPG format, the data used for classification was obtained from direct observation and searching on the internet. The amount of data used was 700 images, the images taken consisted of 14 class characteristics where in each class there were 50 photos which were divided into train and validation data.

2. Data Preprocessing

Image preprocessing by changing the image size of gamelan musical instruments to the same size. The next step is to divide the data that has been collected into two, namely training data and test data. The next step is to label each class character for the introduction of gamelan musical instruments on the training data and test data. At this stage the image rescale, rotation, zoom and horizontal flip processes are also carried out. The goal of the Preprocessing stage is to make the dataset ready to be used by the module for learning.

3. CNN Model Design

CNN design is a stage in compiling a model that is used to train data to recognize the desired object. The model compiled consists of the number of layers used, determining the filter, determining the kernel size, and determining the activation function and pooling size.

4. Model Training

After designing the CNN model, the next step is to train the model using training data that has been collected previously. Next, in the model testing process, the number of epochs (iterations) is used to determine how many times the network will train. At this stage there is a loss function that is used to see the performance of the CNN model.

5. Model Testing

The next stage involves testing the model on test data to assess the extent to which the level of accuracy of the Convolutional Neural Network model can classify gamelan musical instruments well. This level of accuracy shows how much the model can be used as a basis for testing classification in Android applications.

6. Accuracy of Results

The final stage is to determine whether the performance of a classification model is good or not, which can be seen from the performance measurement parameters, namely the level of accuracy, sensitivity and precision. To calculate these factors, a matrix is needed which is usually called a confusion matrix. The confusion matrix contains the values: True Positive (TP), True Negative (TN), False Positive (FP), and False Negative (FN). Evaluation can also be seen in the classification report which directly displays the accuracy, sensitivity and precision values.

3. RESULT AND DISCUSSION

Data Requirements

Gamelan Dataset

The data used in this research comes from 700 images taken using a cellphone camera through observation and internet searches. Using larger datasets allows machines to learn more about different types of objects in images.

1. Training Data

The training data consists of 80% of all existing datasets, thus covering 560 images with 40 datasets per character.

Table 3. Training dataset

Name	Figure
Bonang	

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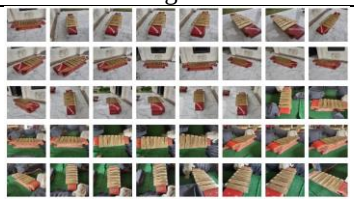
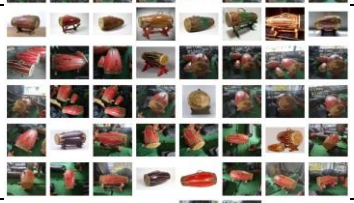
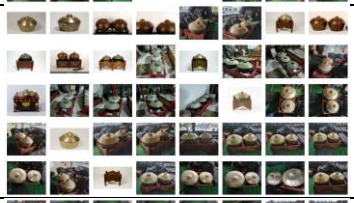
Name	Figure
Demug Saron	
Gambang	
Gender	
Gong	
Kempul	
Kendang	
Kenong	
Kethuk Kempyang	

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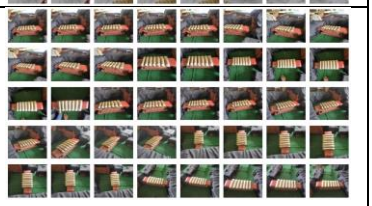
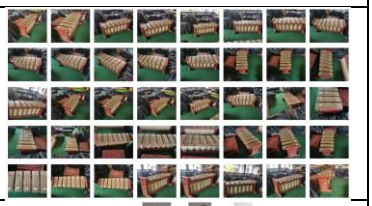
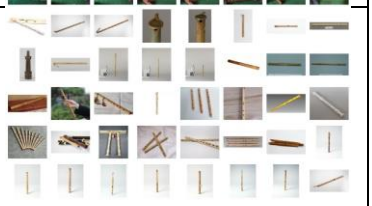
Name	Figure
Rebab	
Saron Barung	
Saron Penerus (Peking)	
slenthem	
Suling	

2. Validation test data

In this process, the validation test data covers 20% of the entire dataset, which means there are 140 images. Each category has 10 images to be used as representatives in the validation data.

Table 4. Testing dataset

Name	Figure
Bonang	
Demug Saron	

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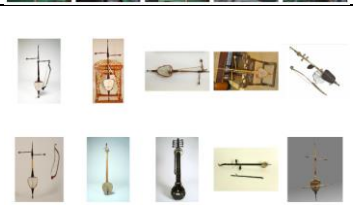
Name	Figure
Gambang	
Gender	
Gong	
Kempul	
Kendang	
Kenong	
Kethuk Kempyang	
Rebab	
Saron Barung	

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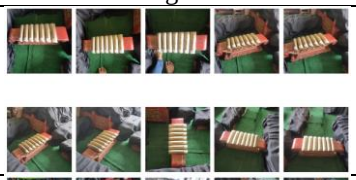
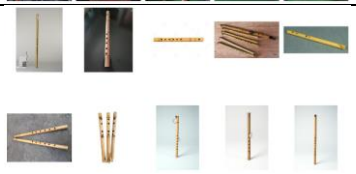
Name	Figure
Saron Penerus (Peking)	
slenthem	
Suling	

User needs explain what user needs are on the functional and non-functional side of the application being built.
1. Application Functional Requirements
Functional requirements are requirements for an application as seen from its feature functions. These requirements contain application development expectations.

Table 5. Application Functional Requirements

NO	Functional Requirements
1	Applications can display information about how to use the application.
2	The App can display information about the App developer
3	The application can display a camera for users to classify Gamelan musical instruments
4	The application can apply the CNN method when classifying Gamelan musical instruments

2. Application non-functional requirements
Non-functional requirements require software information that developers need or use for developing and testing applications. Non-functional requirements can be seen in the following table:

Table 6. Developer Non-Functional Requirements

Type	Non-Functional Requirements
Device	Processor: AMD Ryzen 5 3400G
	RAM: 16GB
	Storage: 120GB
	OS: Windows 11 Pro 64-bit
Device	IDE: Android Studio
	Programming language:
	Kotlin, Python 3.6
	Framework: Tensorflow

Non-functional requirements for users can be seen in the table below:

Table 7. Kebutuhan Non-Fungsional User

Type	Non-Functional Requirements
Device	Android v7.0(Nougat)
Hard	Gapture App

System Design

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1. General System Design

The System Design contains the stages of the System in the Application for Introduction to Gamelan musical instruments.

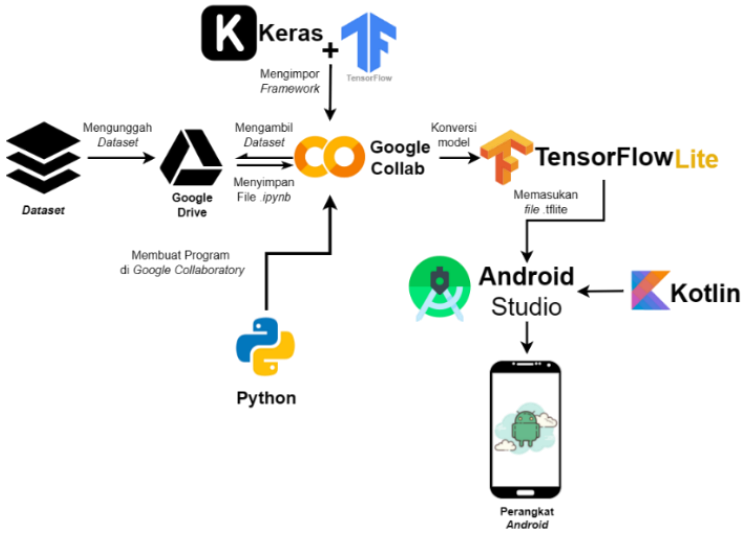
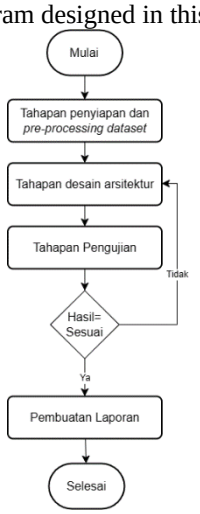


Fig. 3. System Architecture Design

Meanwhile, the system flow diagram designed in this research can be seen in Figure 4



Gambar 4. Flowchart Desain Alur Sistem

2. Use Case Diagrams

Use Case Diagrams describe the functionality of a system being built. In the Use Case Diagram there is a relationship between actors and the system. The following is the planned Use Case Diagram:

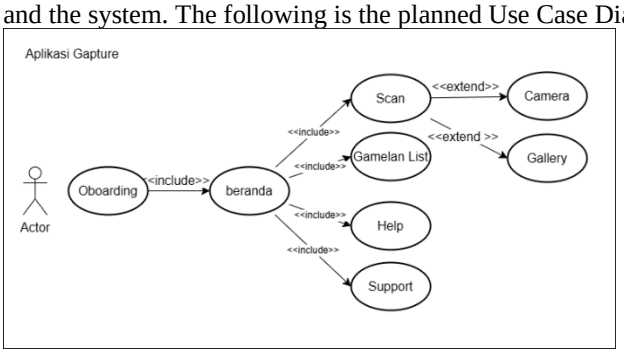


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Fig. 5. Use Case Diagram

3. User Interface Design

The design of the user interface is intended to show what the final result of the Android application for introducing gamelan musical instruments will be.

Table 8. User Interface Design

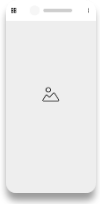
Figure	Information
 Page "*splash screen*"	UI design on the splash screen displays the logo, application name, and name of the application developer
 Page "*Onboarding*"	UI design on the onboarding screen page displays an image slider and skip and next buttons.
 Page "Beranda"	The UI design on the home page displays button options to the user. On this page there are 4 buttons, namely scanning, viewing the gamelan list, help button, and support button
 Page "*Scan*"	On the scan page, users will be given a notification of approval for using the camera. After that, this page displays a choice between using the camera and gallery. And there is also a dashboard button to return to the home screen.
Page "Gamelan *list*"	The UI design on the gamelan list page displays a list of gamelan musical instruments available in the data model.

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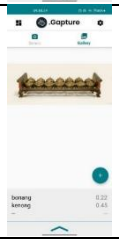
Figure	Information
 Page "*Help*"	The UI design on the help page displays how to use the application and the definition of the application.
 Page "*Support*"	The UI design on the support page displays the developer's personal data.

System Testing

1. Cell Phone Camera Testing

In this case, the test was carried out using a realme cellphone device. With this test, the author can find out the results of the classification of gamelan musical instrument models using a real-time camera and the upload feature in the gallery. Details can be seen in the table as follows:

Table 9. Pengujian Kamera Ponsel

No	Source	Image	Prediction Result	Actual Output
A.	Bonang			
1	GS		Bonang	Bonang
2	GS		Bonang	Bonang
3	GS		Kenong	Bonang

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4	CS		Bonang	Bonang
5	CS		Demug Saron	Bonang
6	CS		Bonang	Bonang

This test was carried out 84 times, with each gamelan musical instrument being tested 6 times, consisting of 3 times using the CS (Camera scan) source and 3 times using GS (Gallery Scan). The test results showed that from a total of 84 experiments, 67 times the prediction results were suitable and 15 times the prediction results were incorrect. So the accuracy percentage can be calculated as follows:

$$\text{Accuracy} = \frac{\text{number of correct predictions}}{\text{amount of data}} \text{ X100\%}$$

$$= \frac{67}{84} \text{ x100\% = 79\%}$$

Based on the results of system testing using a cellphone camera, the classification accuracy value for gamelan musical instruments was 79%.

2. Black Box Testing

Testing using a black box is carried out to determine whether the function of the features in the application meets expectations or not. The test results can be seen as follows:

Table 10. Black Box Testing

No	Test Cases	Test result	Information
1	Starting the application	succeed	Can be opened and displays the splash screen.
2	Pressing the "next and skip" button	succeed	The button can direct the application to the home page.
3	Press the "scan" button	succeed	The button can direct the application to the scan view.
4	Pressing the “camera” button	succeed	Users can distinguish objects in real time.
5	Press the "gallery" button	succeed	The button can direct the application to the gallery page.
6	Press the "upload" button	succeed	Users can classify using data in the gallery.
7	select the “dashboard” button	succeed	The button can direct the application to the home page
8	Pressing the “gamelan list” button	succeed	The button can direct the application to the gamelan list page
9	Pressing the "help" button	succeed	The button can direct the application to the help page
10	Pressing the "Support" button	succeed	The button can direct the application to the support page

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3. Pengujian Confussion Matrix

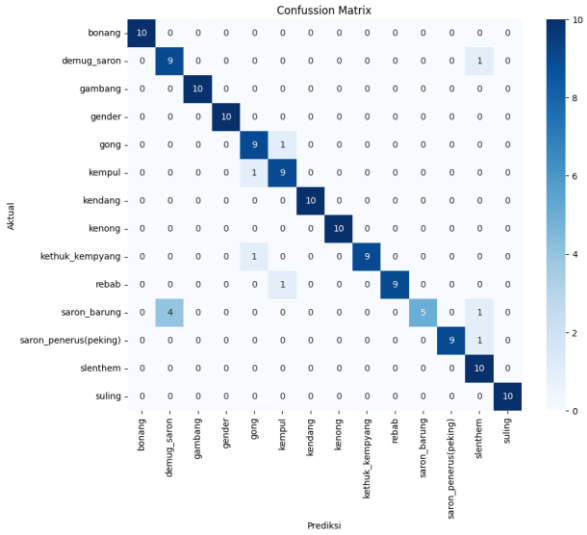

Fig. 6. Confusion Matrix

To determine the performance of the CNN algorithm in this research, it will be tested with several calculations, namely accuracy, precision and recall using the following equation:

$$Accuracy = \frac{TP+TN}{TP+FP+FN+TN} \text{ X100\%} \quad (3.1)$$

$$Precision = \frac{TP}{TP+FP} \text{X100\%} \quad (3.2)$$

$$Recall = \frac{TP}{TP+FN} \text{X100\%} \quad (3.3)$$

Where:
TP (True Positive) = the amount of correct data that is correctly identified by the system.
FP (False Positive) = the number of correct data but identified as incorrect by the system.
FN (False Negative) = the number of incorrect data but identified as incorrect by the system.

Table 11. Hasil Confusion Matrix

	precision	recall	f1-score	support
bonang	1	1	1	10
Demug saron	0.69	0.9	0.78	10
gambang	1	1	1	10
gender	1	1	1	10
gong	0.82	0.9	0.86	10
kempul	0.82	0.9	0.86	10
kendang	1	1	1	10
kenong	1	1	1	10
Kethuk kempyang	1	0.9	0.95	10
rebab	1	0.9	0.95	10
Saron barung	1	0.5	0.67	10
Saron penerus (peking)	1	0.9	0.95	10

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slenthem	0.77	1	0.87	10
suling	1	1	1	10
accuracy			0.92	140
macro avg	0.94	0.92	0.92	140
weighted avg	0.94	0.92	0.92	140

According to the results of the calculations above, it can be concluded that the accuracy of the Convolutional Neural Network (CNN) algorithm in classifying gamelan musical instruments received an accuracy value of 92%.

User Interface Results in Applications

Table 12. User Interface Results in Applications

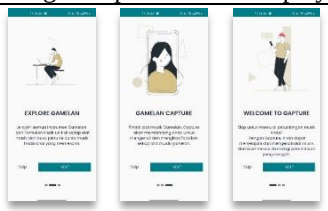
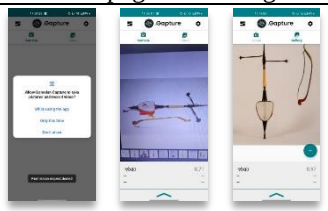
Figure	Information
 Image of splash screen display	The splash screen is the initial screen that appears when opening an application, displaying the logo and name of the application. This provides the initial impression and identity of the application.
 Image of onboarding display	Onboarding is a series of layers that appear after the Page splash screen when the user first opens the application. These screens are user designed to guide the user through the main functions and features of the application.
 Homepage view image	The application home screen is the main screen in the application that appears after the onboarding process. On this homepage there are four buttons designed to make it easier for users to access the features contained in it. In this case, the features on the home screen include the scan button, gamelan list, help and support buttons.
 Image Scan display	This menu functions as the main feature of the application which is used to recognize and differentiate the visual characteristics of gamelan musical instruments using the convolutional neural network (CNN) method.
 Image of gamelan list display	This display is used to display a list of gamelan in the application which is useful for making it easier for users to recognize gamelan musical instruments

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Figure	Information
 Image Display help	This menu functions to display step-by-step instructions for running this application.
 Support Display Image	This menu functions to find out the identity of the application developer.

4. CONCLUSION

Based on research that has been carried out to classify images for recognizing types of gamelan musical instruments based on pattern shapes using the Android-based Convolutional Neural Network (CNN) method, it can be concluded that the use of the Convolutional Neural Network (CNN) algorithm is quite good in classifying image types. - types of gamelan musical instruments, including:

1. Convolutional Neural Network can be implemented successfully for image classification for recognition of types of gamelan musical instruments on an Android-based system. This shows that the CNN method is able to provide satisfactory results in recognizing complex visual patterns on gamelan musical instruments.
2. In the test results stage of the training model using input measuring 640 x 640 pixels with an epoch value of 100, trials were carried out with a testing dataset of 700 data with 14 class categories. The accuracy results obtained reached 98% with a total of 11 errors. tested dataset. Meanwhile, system test results on Android-based applications with independent testing 84 times showed accuracy results of 79%, with a total error of 17 data from the total test dataset. This confirms the reliability of the CNN model in classifying types of gamelan musical instruments even though there is a slight variation in results between the model training and application test stages.
3. The classification model is deployed using TensorFlow Lite on the Android application, namely MobilNetV2. This model was trained using a dataset of types of gamelan musical instruments, which means this model cannot recognize objects outside that dataset.

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