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Design of Batak Toba Script Recognition System Using Convolutional Neural Network Algorithm

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Abstract: Indonesia is one of the countries with diversity and abundant cultural wealth, one of which is the Batak Toba script as one of the wealth originating from the Batak tribe. However, the existence of the Batak Toba script is decreasing along with the rapid development of the times, due to the lack of interest of the younger generation and public awareness in preserving the Batak Toba script. From these problems, the author conducted research to create a model of introducing the Batak Toba script, as an effort to preserve the Batak Toba script which is one of Indonesia's cultural wealth. The purpose of this research is to create a Batak Toba script recognition model using a digital handwriting dataset, and has an output in the form of visual text and with audio pronunciation of each script. The method used in this research is the Convolutional Neural Network algorithm combined with RMSprop optimizer. Convolutional Neural Network is an algorithm that is one of the deep learning methods that has good performance on image data. The results of this study incised a recognition model with a relatively high level of accuracy, which is equal to 99,54% which was tested on the Batak Toba script dataset in the form of digital handwriting. Through this research, the model using the Convolutional Neural Network algorithm used in this research is able to produce good results for recognizing the Batak Toba script in the form of handwriting.

Keywords: Batak Toba Script, Convolutional Neural Network, Deep Learning, Recognition, Handwriting

INTRODUCTION

Indonesia is a country that consists of a diversity of ethnic groups and cultures that are so rich. One of the rich cultures and ethnic groups in Indonesia is the cultural wealth of the Batak tribe. The Batak tribe lives in North Sumatra and its surroundings, and has traditions and cultural systems that are so rich and diverse, ranging from the famous Ulos cloth to foreign countries, traditional ceremonies that are so sacred, to the language heritage of the existing ancestors. or better known as script. The script is one of the communication media shaped like speech used by humans, a visual system consisting of symbols written on various mediums, such as paper, stone, trees, wood, or cloth, which are used to convey expressive aspects of a language (Roza 2017).

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The Batak Toba script is script is one of the scripts which is commonly used among the Batak tribe, but its use was still very limited in ancient times so there was a lack of information and people who understood the Batak Toba script. In ancient times, the use of the Batak Toba script was limited to leaders, medical experts, and traditional experts (Pratama et al. 2023). However, the existence and knowledge of Batak Toba script is decreasing, mainly due to technological developments that occur and the lack of interest for new generations to learn the understanding of Batak script itself (Pasaribu and Hasugian 2015). This certainly cannot be underestimated, because it can result in the loss of Batak script culture due to no one who can understand and recognize the Batak script itself. For this reason, the Batak script must be preserved to maintain its existence, so that the existing cultural values of the Batak tribe itself do not fade and can be maintained. However, automatic recognition and detection of the Batak Toba script is still a significant challenge. Current detection methods tend to rely on manual approaches, such as character segmentation and pattern recognition based on certain rules. This approach not only requires a lot of time and effort, but is also prone to errors and has limitations in recognizing the variety of character shapes that may occur in writing.

As one of the cultural heritages that need to be inherited, the author conducted research to make a detection of the Batak Toba script using the CNN (Convolutional Neural Network) method which will recognize the Batak Toba script and then produce output not only in the form of Latin text, but also in the form of sound. CNN is a neural network specifically designed to process 2-dimensional data such as visual images or objects in an image, including one type of deep neural network and consists of neurons with weight, bias and activation functions as the parameter (Nugroho, Fenriana, and Arijanto 2020). The author chose the CNN method because based on similar research that has been done, the CNN method has a high level of accuracy in recognizing data in the form of images. The accuracy rate produced using the CNN method in similar research that has been done before reaches 84.08% (Pratama et al. 2023), 97.3% (Dharma, Tambunan, and Naibaho 2022), and 95.04% (Lorentius, Adipranata, and Tjondrowiguno 2020) in the implementation for script detection.

In this research, the author focuses on the recognition of the Batak Toba script, specifically on the script called *ina ni surat* or often called *si sia* or *surat sampulu sia* because the number of characters available is nineteen. The Batak Toba script has the nature of writing like Latin letters, namely from right to left. In addition, the writing of the Batak Toba script does not have punctuation marks such as periods and commas, uppercase and lowercase letters, and is a consonant letter that has the ending sound "a" (Pasaribu and Hasugian 2015).

The purpose of this research is to preserve one of Indonesia's cultural treasures, namely the Batak Toba script, assessing the importance of existing cultural values and existence. In this research, the author creates a model of recognizing the Batak Toba script in the form of handwriting that produces output not only in the form of Latin text, but also produces output in the form of sound. This is intended to provide easy accessibility for people who have visual limitations. The author also aims to create a new dataset created by the author, and use a new approach using the CNN method, to recognize the Batak Toba script in the form of digital handwriting. The results of this research are believed to have good results, and are expected to have a positive impact on the preservation of Batak culture, especially among teenagers to young adults. In addition, through this research the author also hopes that the results of the research produced can make a real contribution to the importance of preserving the Batak Toba script as a cultural heritage, as well as contributing to the Indonesian government in preserving the culture of the Batak tribe so that it is not timeless.

METHOD

This research uses qualitative method as the research method. The methods used in this research includes Convolutional Neural Network as the main algorithm, which is supported by the TensorFlow library. In this research, the author developed a Batak script pattern recognition model in the form of digital handwriting, with audio output to help pronunciation and facilitate access for people with disabilities. The main stages carried out are divided into 8 stages, which can be seen in the following flowchart in Fig. 1:

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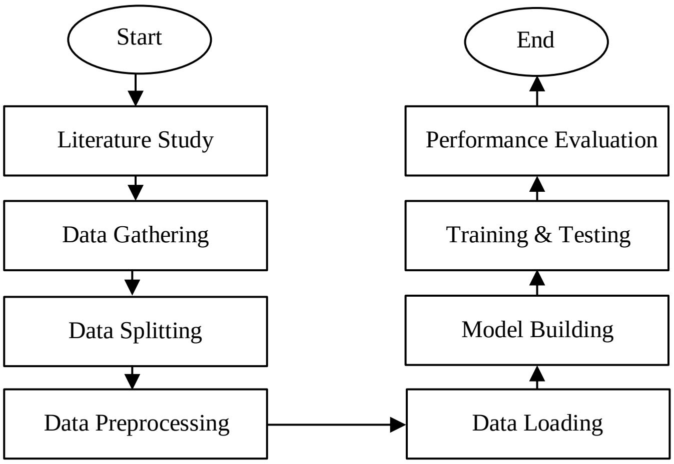

Fig. 1. Research Stages Flowchart

In the first stage, the author conducts a literature study first to explore information to support the research conducted from various sources such as similar research journals, as well as books that discuss the Batak Toba script and the use of the CNN algorithm spread across the internet. After obtaining the information needed, the author and all respondents then immediately made an image dataset of each Batak Toba script, or *ina ni surat*, which amounted to 19 characters consisting of *a*, *ha*, *ma*, *na*, *ra*, *ta*, *sa*, *pa*, *la*, *ga*, *ja*, *da*, *nga*, *ba*, *wa*, *ya*, *nya*, *i*, *u*. The dataset used not only contains the author's handwriting, but also the handwriting of ten respondents. Images of each Batak Toba script used in this study, as well as handwriting samples from each respondent can be seen in the following Fig. 2 and Fig. 3:

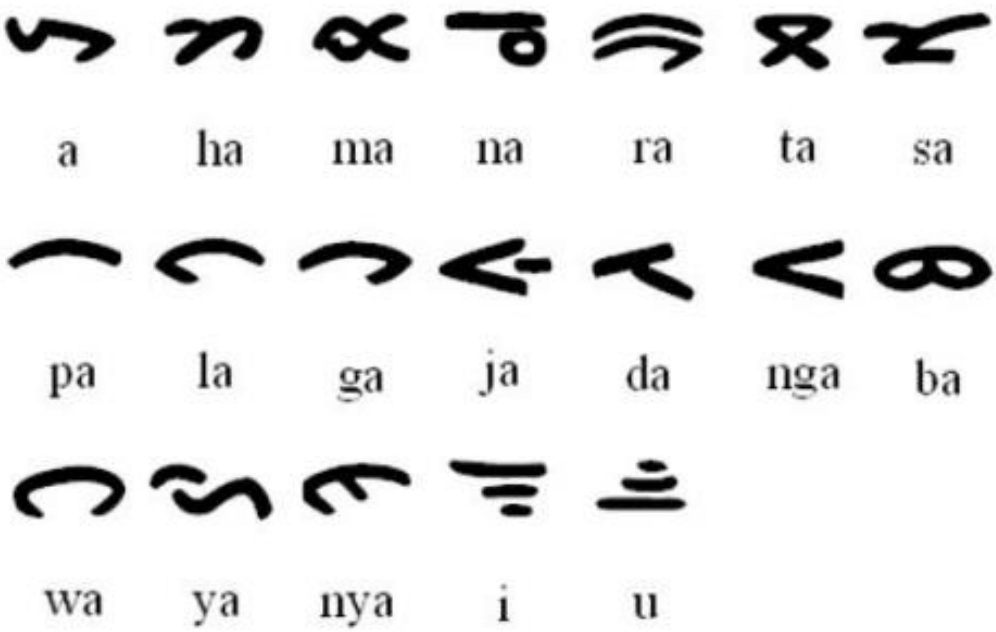

Fig. 2. Batak Toba Script as Known as *ina ni surat* (Pasaribu and Hasugian 2015)

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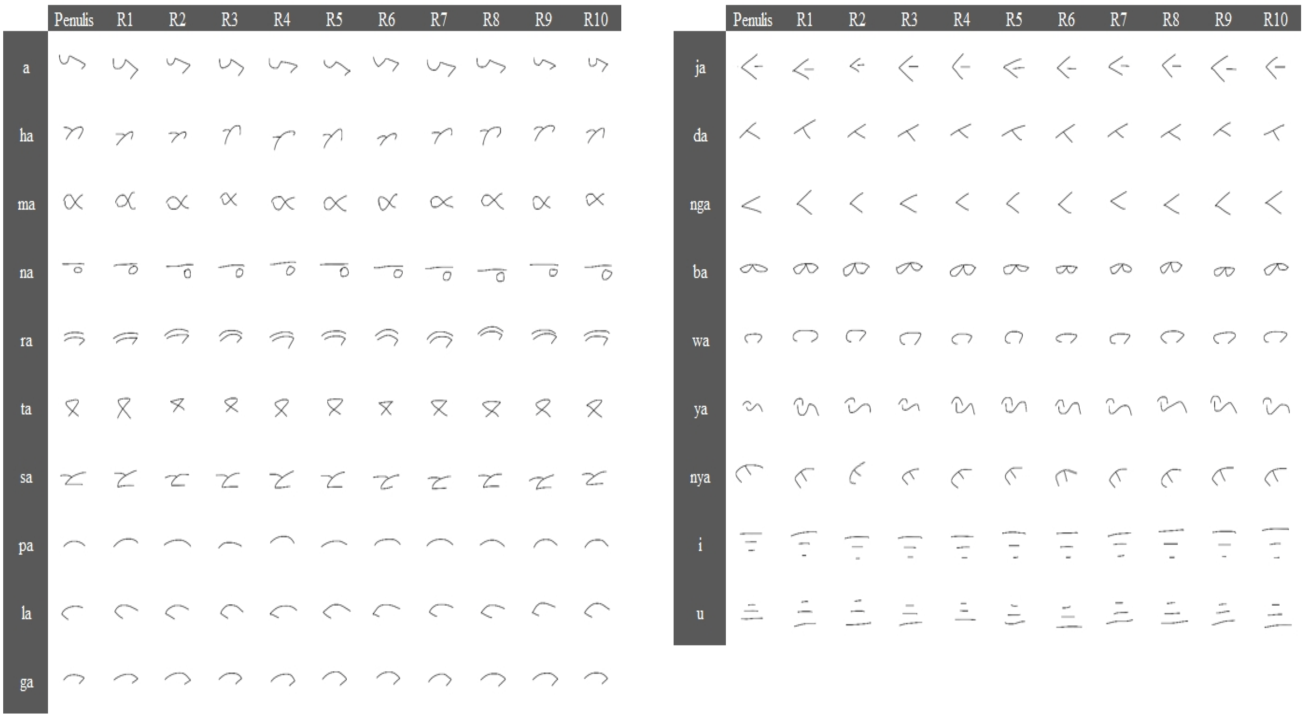

Fig. 3. Sample Data of Batak Toba Script Handwriting Made by the Author and 10 Respondents

The author and all respondents used the "Sketchbook" application to create digital handwriting image data of each script in .png format. The author and 10 respondents each generated 100 data for each script, totaling 1,900 data from each author and each respondent. To increase amount of data, data augmentation process was performed. Increasing the amount of data that can be implemented with the aims to improve model performance. The author uses one of the features provided by the TensorFlow and Keras libraries, namely ImageDataGenerator. The data generated amounted to 1.790 data, the flowchart of the data augmentation process can be seen in Fig. 4:

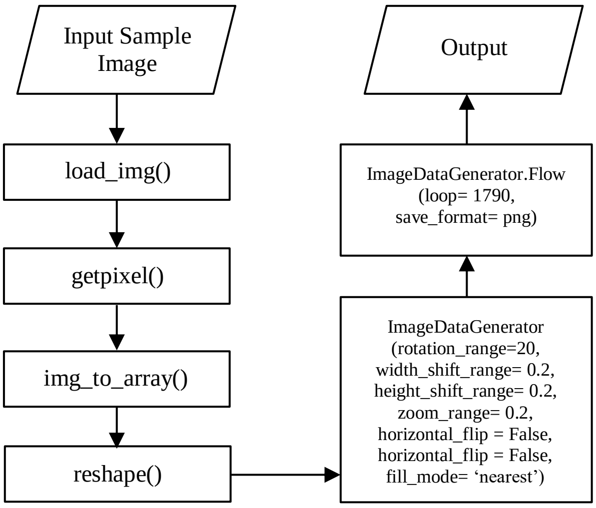

Fig 4. Data Augmentation Process Flowchart

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First, the data that will be sampled in the model for data generation is entered. The data entered is then extracted for each pixel value, then converted into an array with a size of 1000 x 1000 x 3 which means it has a height and width of 1000 in the form of a 3-dimensional array. Before being entered into the data generation function, a reshape is performed by adding 1 additional array dimension, because the ImageDataGenerator() function requires an image with a 4-dimensional array to work (Joichiro 2022). After reshaping, the data is input into the ImageDataGenerator() function which is run 1.790 times to generate 1.790 images for each script. The augmentation process was carried out for each Batak Toba script, so the total data generated through the augmentation process amounted to 34.010 data.

Image data from each script totals 2.890 data, with a total of 54.910 data from 19 scripts along with 19 audio files from each script. All data was saved to local folder for easier access. All existing data has passed the cleaning stage to eliminate anomalous data, such as blurred image data to maximize model performance. After data gathering stage, data splitting is performs to divide the dataset into 2 parts, namely training and testing datasets. The author uses a ratio of 9 to 1 to divide the data for each script, with a ratio of 9 for training data, while a ratio of 1 for testing data. After dividing the data, the amount of data is divided into 2.601 training data and 289 testing data for the 19 existing characters. After the division, the overall dataset has 49.419 training data and 5.491 testing data. The data that has been divided is then processed further in the data preprocessing stage.

In the data preprocessing stage, several stages are carried out starting from grayscale, edge tracking, contouring, and resizing. Each stage is carried out to prepare each data so that it can be processed properly when implemented into the Convolutional Neural Network model in the next stage. First of all, each image first goes through a stage to change the color format from BGR (Blue, Green, Red) to GRAY, where the image that previously had 3 color compositions per pixel is changed to only have 1 color composition with varying intensity (Rizki and Hariadi 2019). Grayscale aims to increase the contrast of an image, so that the information in it can be extracted better and more visible (Qudsi, Asmara, and Syulistyo 2019). The grayscale stage is the initial stage that must be done before entering the edge tracking stage, in order to minimize the noise detected when entering the next stage. In the next process, the author uses the Canny Edge Detection algorithm for the edge tracking stage. The edge tracking stage is carried out to connect edge pixels contained in an image with the aim of extracting useful structural information on an image object and is commonly used in computer vision systems (Utari and Zulfikar 2023). After the data passes the edge tracking stage, the data preprocessing stage continues to the contouring stage. In the contouring stage, a line is formed that connects points on the edges of objects in an image continuously. This process is done to avoid the detection of lines and fine points from being detected as edge lines (Rahman and Sukemi 2019). After passing the contouring stage, then resize the entire existing image data so that it has a uniform size, which is 150 x 150 pixels.

After the preprocessing stage, classes were created according to the names of each script to load each data according to its class at the data loading stage. At the data loading stage, load all the data that will be entered into the model. The author then proceeds to create a Convolutional Neural Network model that will be used to recognize each Batak Toba script. The model that the author created consists of four convolutional layers to perform feature extraction with the output in the form of a feature map, with the number of each conv filter totaling 64, 128, 256, and 512 in each layer. Each layer has a kernel size of 3x3, and the stride value or pixel shift in each movement is 1 (default value). For the fully connected layer that serves as the one that unifies every information generated through the convolutional layer, the author uses 1 flatten layer, along with 2 dense layers. The output produced through the convolutional layer stage first enters the flatten layer, to change the dimension of the data from three-dimensional data to one-dimensional data (Fu'adah et al. 2020). Each dense layer has different parameters, where the first dense layer has a parameterized number of neurons while the second dense layer has a parameterized number of classes. Dense layer functions to classify and calculate the highest probability of each target class. The author also adds a dropout layer to eliminate unnecessary regulations to avoid overfitting/underfitting the model when entering the training data stage (Reddy, Rao, and Raju 2019). A flowchart containing a detailed information of every layer that have been used this model can be seen in the following Fig. 5:

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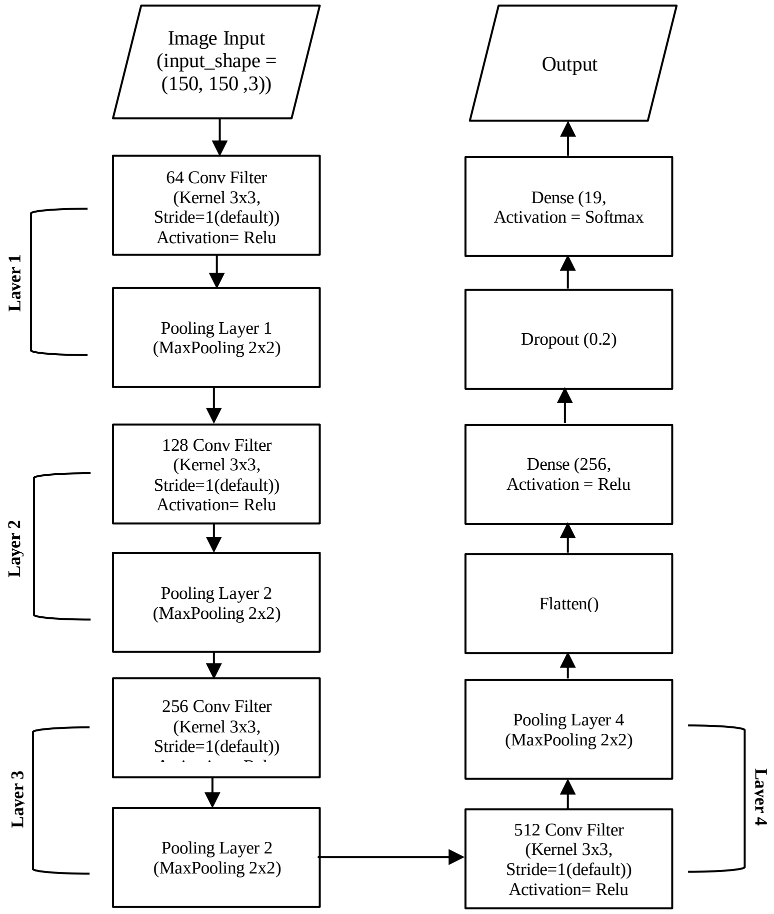

Fig. 5. Model Architecture Flowchart using Convolutional Neural Network algorithm

After designing the model, the data is then entered into the model to start the training stage. Experiments have been conducted to implement 3 different types of optimizers, namely SGD (Stochastic Gradient Descent), Adam and RMSprop. Optimizer is a method used to change values and attributes with the aim of reducing the loss value that arises during the data training process (Kurniawan et al. 2023). The author uses 5 epoch parameters with 161 validation cycles and validation_split of 0,2 for data at the training stage. After passing the model training stage, the research continued to the testing stage to evaluate the model that had been created. Visualization is presented in the form of a plot diagram and confusion matrix, along with parameters to show the performance of the model that has been made in the form of a percentage of accuracy.

RESULT

Based on the training data process that has been carried out, the author conducts testing using testing data to evaluate the performance of the model in recognizing the Batak Toba script. The evaluation will be presented in the form of a plot diagram, confusion matrix, along with the percentage of accuracy that indicates the performance of the model that has been made.

First of all, the three optimizers that have been implemented to the designed model are compared to find the optimizer with the best performance. Based on the three tested optimizers, it is found that the accuracy of the RMSprop optimizer is the highest compared to the SGD and Adam optimizers. A diagram showing the accuracy of each optimizer can be seen in Fig. 6:

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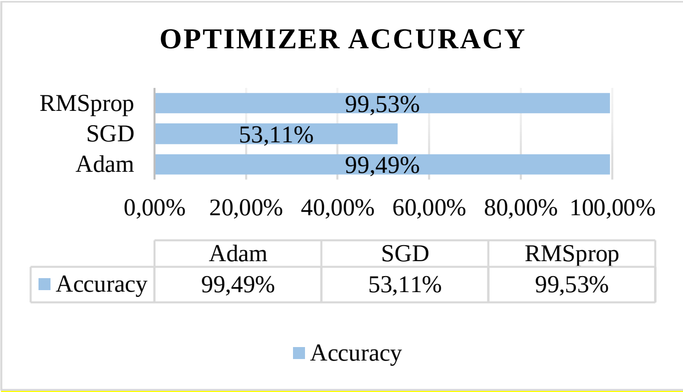

Fig. 6. Data comparison table of each optimizer

Despite using a small number of epochs/iterations, some optimizers managed to achieve a good performance in recognizing the Batak Toba script. Based on the above comparison, RMSprop is the optimizer that has best performance, achieving accuracy rate of 99.53%, followed by the Adam optimizer with a very small difference in accuracy of 99.49%, followed by the SGD optimizer which has the worst accuracy value compared to the RMSprop and Adam optimizers which is 53.11%. Based on these results, the authors decided to use the RMSprop optimizer as the optimizer to be implemented in the model. RMSprop is one of the optimizer methods, which has a fast and efficient performance and is a model development of Rprop, which cannot be used for large datasets (Ahsan et al. 2020; Reddy et al. 2019). The model created successfully recognizes the Batak Toba script well, which can be seen through a plot diagram that shows a relatively high accuracy value, as well as a low loss value. The plot diagram can be seen in Fig. 7:

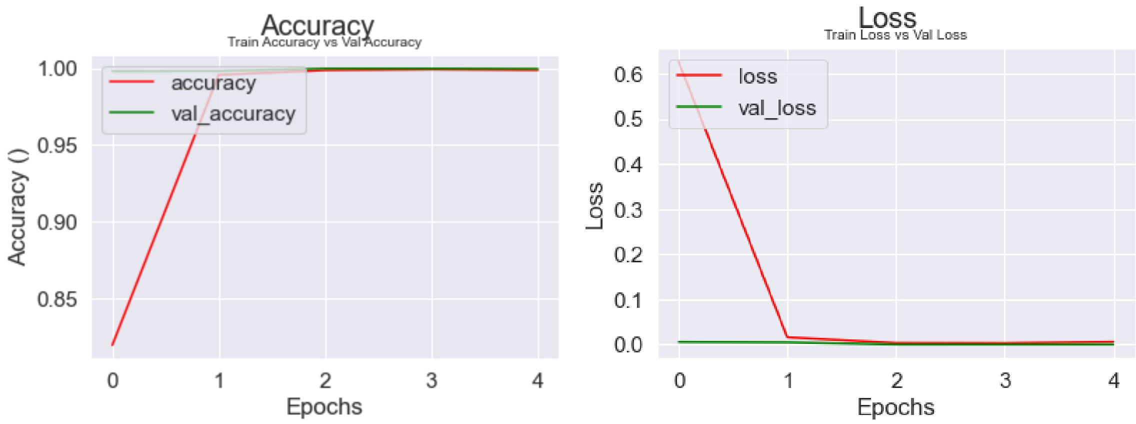

Fig. 7. Accuracy Plot Diagram of RMSprop Optimizer (Left) and Data Loss Plot Diagram of RMSprop Optimizer (Right)

Based on the diagram presented above, it can be concluded that the accuracy and loss curves of the validation data have curves that are aligned with the training data. This shows that the performance of the model created can be categorized as optimal fit. The author then conducts testing using testing data on the Convolutional Neural Network model against random testing data. This is intended to validate the performance of the model in recognizing the Batak Toba script. The results of the testing provide output in form of a prediction label for the Batak Toba script along with the audio of the script, which can be seen in Fig. 8 below:

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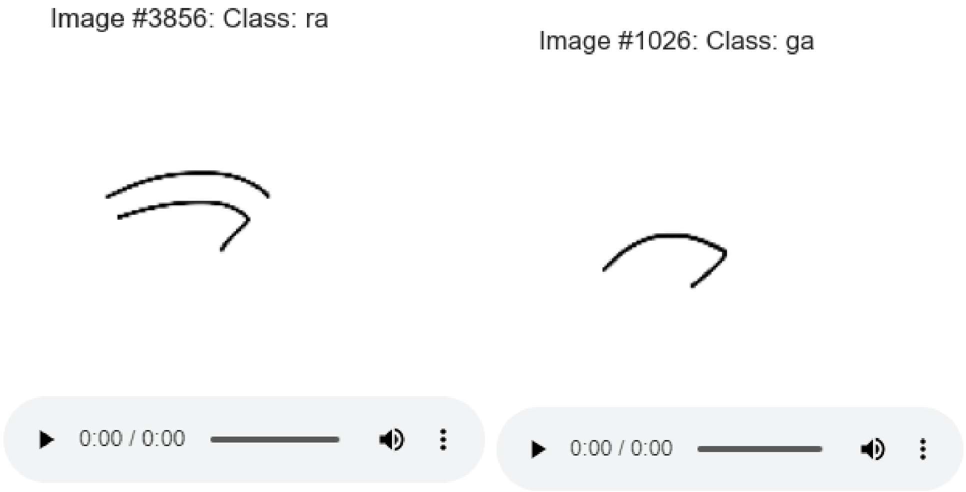

Fig. 8. Test results on randomized testing data

Based on the testing results, recognition model succeeded in recognizing the Batak Toba script well without any errors on randomized data. To visualize the performance testing of the model that has been made as a whole, can be through the confusion matrix in the following Fig. 9:

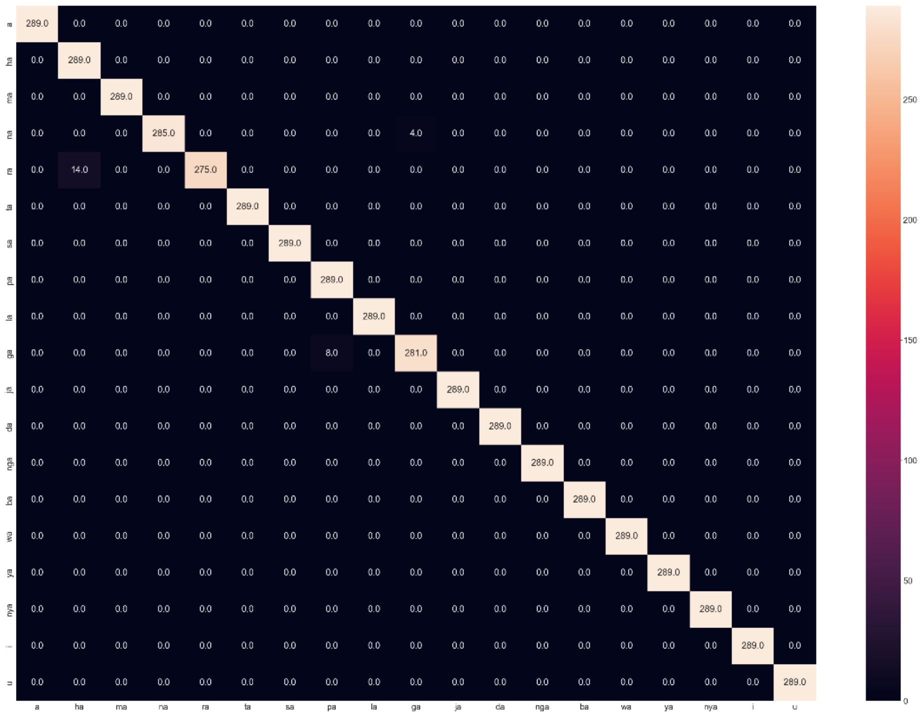

Fig. 9. Confusion Matrix of the model with Convolutional Neural Network algorithm

Based on figure above, the implemented model performs well against the dataset of handwritten Batak Toba script in digital form. Of all the testing data, the model only makes 3 recognition errors on different characters, namely in the characters "na", "ra", and "ga". with 4, 14, 8 script recognition errors against the testing data respectively, or it can be concluded that 26 data in total. To objectively measure the performance of the model, it can be done by performing mathematical calculations which can be seen as follows:

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$$Accuracy = \frac{Total\ of\ correctly\ recognized\ data}{Total\ testing\ data}$$

Then based on these calculations, the accuracy value of the recognition model with the Convolutional Neural Network algorithm and the RMSprop optimizer can be seen as follows:

$$Accuracy = \frac{5465}{5.491}\ x\ 100\% = 99{,}53\%$$

DISCUSSIONS

In this research, a system is made to recognize the Batak Toba script in the form of handwriting. There have been many previous studies that still use computer-generated data for the training data used, resulting in results that are not optimal when recognizing handwriting. This is due to the lack of variation in training data carried out, so that the system will have difficulty when recognizing handwriting that has a writing pattern that is far from the data used for training when making models.

The Batak Toba script recognition system in this study, has a variety of training data that has a diversity of writing forms and an amount that is superior to previous studies (Dharma et al. 2022; Pasaribu and Hasugian 2015; Pratama et al. 2023; Tambunan 2019). A system that has a larger amount of training data will produce a recognition system that is more flexible in recognizing a more diverse Batak Toba script.

CONCLUSION

The results of the research conducted stated that the model with the CNN (Convolutional Neural Network) algorithm succeeded in incising an accuracy rate of up to 99.53% with a low error rate of 0,47% based on the test data on the dataset, in accordance with the problems that became the author's research objectives to preserve the cultural wealth of the Batak tribe which is one of the cultural diversity owned by Indonesia can be timeless, and create a model of imposition of Batak Toba script that produces not only Latin text output, but also produces audio that can help the pronunciation of the Batak Toba script itself. Through this research, the author hopes to contribute to increasing knowledge about models for recognizing the Batak Toba script. The author also hopes that the model used can be developed and used for further research. Suggestions from the author for future research are the addition of datasets to perform word recognition, or even sentences. In addition, an application can also be produced either in form of web or mobile based applications to make access easier.

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