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# Preface: The 3rd International Conference on Natural Sciences, Mathematics, Applications, Research, and Technology (ICON-SMART) 2022

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# Preface: The 3rd International Conference On Natural Sciences, Mathematics, Applications, Research, and Technology (ICON-SMART) 2022

Welcome to The 3rd International Conference On Natural Sciences, Mathematics, Applications, Research, and Technology (ICON-SMART) 2022 organized by the Faculty of Mathematics and Natural Sciences, Universitas Sam Ratulangi in collaborations with The Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Sam Ratulangi (UNSRAT) Manado, in collaboration with the Graduate School of Environment and Information Sciences, Yokohama National University (YNU), Japan, the Faculty of Science, Prince of Songkla University (PSU), Thailand, FMIPA Universitas Pendidikan Ganesha (UNDIKSHA), Universitas Udayana (UNUD), Universitas Mataram (UNRAM), Universitas Negeri Malang (UM), Universitas Cenderawasih (UNCEN) Jayapura, Faculty of Biology, Universitas Kristen Satya Wacana (UKSW) Salatiga, Universitas Negeri Gorontalo (UNG), and supported by the Indonesian Network of Higher Educations of Mathematics and Natural Sciences (MIPAnet), and Majlis Dekan Sains dan Matematik (MSM) Malaysia, which was held as a hybrid conference with physical venue at Discovery Kartika Plaza Hotel, Kuta, Bali, Indonesia, on 3-4 June 2022.

ICON-SMART is an annual event. It provides a platform to researchers, academicians, professionals, educators, and industries to share and generate interests in cutting-edge research, applications, education, and technology in the related areas. The COVID-19 pandemic has disrupted conventional education systems, has caused great challenges to the energy industry, and has emphasized the importance of food security. As a maritime country, the latter points to the need for strengthening marine industries. Therefore, this year conference will concentrate on three important aspects namely, education, energy efficiency, and marine industries. The theme of the conference was chosen in conjunction with these three important aspects from mathematical physics and biotechnology points of view. The Covid-19 recovery process after the pandemic demands suitable and better models, systems, materials, and tools for teaching, learning, and research, more alternatives of renewable energy sources, and more productive and environmentally friendly marine industries. This was the motivation of choosing the theme: *Mathematical Physics and Biotechnology for Education, Energy Efficiency, and Marine Industries* for the 3rd ICON-SMART.

The 3rd ICON SMART 2022 counted 7 prominent plenary and invited speakers from Thailand, Japan, Malaysia, and Australia, 4 workshop speakers from Japan and Thailand, 48 Deans from Indonesia and Malaysia, 72 Vice Deans and Head of Departments, 600 other general participants, and 854 students. The participants were form 239 universities and institutions from 16 countries. This conference resulted in 137 papers submitted, under which 99 of them will be published in AIP Conference Proceeding indexed by Scopus and Web of Science.

The 4th ICON SMART was conducted in Manado on 21-22 September 2023. You are mostly welcome to join.

*Pakatuan wo Pakalawiden.* God bless you.
Faculty of Mathematics and Natural Sciences, Universitas Sam Ratulangi.
Dean,
Prof. Dr. Benny Pinontoan, M. Sc.

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# Balinese script transliteration: A preliminary study

Stephanus Felix Suryanto; Anastasia Rita Widiarti; Hari Suparwito

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# Balinese Script Transliteration: A Preliminary Study

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**Abstract.** A Balinese script is one of the cultural relics of our ancestors and can be found in palm leaves. However, today Balinese script is abandoned along with the increasing use of the Roman script. Some efforts are needed for continuous socialization by developing the Balinese script learning media. We proposed the Balinese script identification using a machine learning approach. The backpropagation neural network algorithm is applied to create a predictive model recognizing Balinese scripts. Our study used 1001 Balinese character images extracted with the intensity of character algorithm, mark direction, and length and width of the character images methods. The result is promising. The training data accuracy is 90.31%, and the single testing data accuracy is 94%. The predictive model result shows the opportunity to develop a transliteration of Balinese script apps using the machine learning technique.

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## INTRODUCTION

The script is an image, writing, or a symbol written or drawn on a medium such as paper, papyrus, palm leaf, stone, and other media that describes the meaning of the language. The script has been used since ancient civilizations as a medium of communication. In Indonesia, there are a variety of local scripts which illustrate and characterize the specific local culture. For example, on the island of Sumatra, there are scripts from Aceh, Batak, Rejang, and Lampung. On the island of Java, there are Javanese and Sundanese scripts. On the island of Sulawesi there are Bugis, Mandar and Makasar scripts. Likewise, the island of Bali has its script [1].

Nowadays, many people abandon local scripts. The main reason is that most of the local scripts are from the past. They are challenging to identify. Many of them are damaged, or the writing is blurry. Therefore, local scripts are rarely used and are difficult to learn. Many people switch to Latin script; therefore, first, we must recognize the scripts to overcome this problem, especially if the writing is damaged or blurry. Secondly, modern media such as games or interactive media are needed for local script learning, especially for youth.

We proposed a machine learning approach using an Artificial Neural Network (ANN) algorithm to recognize Balinese scripts. Some previous studies showed that a machine learning approach is a potential method to identify scripts such as [2], achieving an average Devanagari script recognition accuracy of 99.27%. The feature extraction method was a piecewise histogram of oriented gradients (HOG). The algorithm for its recognition was the artificial neural network classification algorithm or ANN. The resulting accuracy was very high, even though what was recognized was handwritten scripts. Setiawan, Prabowo, and Puspaningrum achieved 74% accuracy in recognizing Javanese scripts using ANN [3]. The ANN allow to obtain a high recognition speed and accuracy for identifying Cyrillic letters in Braille. The system can dynamically adapt to factors such as the quality of the input models and the differences between them [4]. The license plate recognition algorithm based on SVM and ANN neural network is effective in solving the problem of license plate recognition. The SVM classification is used to judge whether the detected area is a license plate. The ANN neural network is used to recognize plate characters [5].

Another study using the Convolutional Neural Network (CNN) method for Hiragana script recognition achieved an accuracy of 95% [6]. Avadesh and Goyal propose a CNN-based optical character recognition (OCR) system that accurately digitizes ancient Sanskrit manuscripts (Devanagari script) that are not necessarily in good condition. Their OCR system was concluded to be resistant to various noise related to manuscript quality, due to contaminated and

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poorly maintained manuscripts [7]. This paper presents the research results that use ANN for handwritten Balinese script recognition. The success of this research would allow researchers to develop the system as a tool for teaching Balinese transliteration of the script to the community.

## METHOD

In general, the process we have done is illustrated in Fig. 1. The first process is loading the dataset and putting it in the system. Next, the image would be preprocessed to make the image more suitable for further processing, that is, the feature extraction process. The feature extraction process will generate a new data representation of each image as a parameter for the transliteration process. The final process is a transliteration, which means changing Balinese scripts to be ready for analysis using an ANN algorithm.

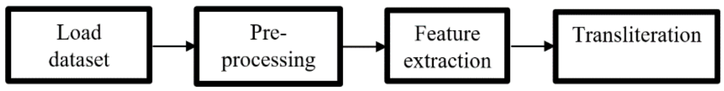



**FIGURE 1.** The proposed method

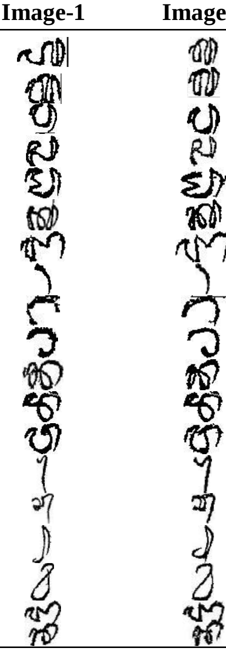
### Dataset

The dataset is the image of a handwritten Balinese script on palm leaves or *lontar*. The *lontar* is from a collection of the Artati Library of Sanata Dharma University. We used *lempir* 1 to *lempir* 4 only, where the left and right parts of each *lempir* were separated. The digitization of *lontar* leaves was done using a digital camera with a resolution of 18 megapixels with a size of 5l84 x 3456 pixels. The camera was placed on *lontar* leaves at about 30 cm.

The results of digitizing the data (images) are then segmented. Based on the minimum amount of data adequacy for the classification process, not all image segmentation results are used. In this study, only 1001 images were used for 18 types of Balinese scripts. Each image script has a number ranging from the least amounting to 20 and the largest amounting to 121 images. Table 1 below shows sample data of the Balinese script image.

**TABLE 1.** Sample image dataset

| Label | Image-1 | Image-2 |
|---|---|---|
| Ha | | |
| Ta | | |
| Pa | | |
| Sa | | |
| Ma | | |
| Ka | | |
| Nga | | |
| Koma | | |
| Ulu | | |
| Tedong | | |
| Na | | |
| Da | | |
| Wa | | |
| Taleng | | |
| Ra | | |
| Ya | | |
| Gantungan wa | | |
| Ngka | | |



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## Preprocessing

Preprocessing is the step where all data is made to be uniform in color, size, and thickness. Fig. 2 shows the preprocessing steps of 5: Binarization, Cropping, Inverse, Resize, and Thinning. In Binarization, the color intensity of the image is converted into a binary image, which is an image that only has values 0 and 1. The process made the image's color the same while saving computational costs.

The second step, cropping, remove the image's white background so that only the image of the scripts is obtained without extra space. The profile projection method determines the image's upper, lower, left, and right boundaries. Next, we did inverse, which is done to change the color of the image from a black object and a white background to a white object and a black background. This stage uses the implement() method, the default software function that changes 1 to 0 and 0 to 1.

Resize is the following step after cropping. Resize could make the image size the same. At this stage, the size is adjusted to its importance to be appropriately recognized in the feature extraction process. This step is done with the imresize() function. The last process is the Thinning stage. The thinning means removing the object pixels that are the edges of the image so that the remaining pixels are the frame of the image only. The thinning method used the bwmorph() function which is available in a certain software.

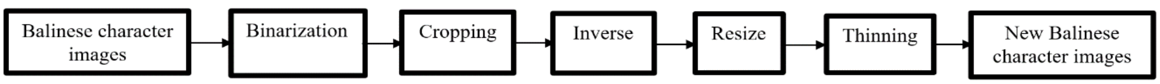
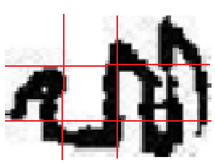



**FIGURE 2.** Preprocessing steps

## Feature Extraction

Feature Extraction is an essential process in this research. Three feature units were used for each image, namely the Intensity of Character (IoC) feature, the Mark Direction (MD) feature, and the original size feature of the length and width of the image before being subjected to preprocessing. IoC aims to obtain the characteristic number of black pixels from the character image in the nine areas after the image is divided into n × n areas, as illustrated in Fig. 3 (a) [8]. The image is divided into three rows and three columns, resulting in 9 new areas. In each area of the original image division, the number of black pixels is calculated, as shown in Fig. 3 (b). Because there are nine new areas, there are also nine corresponding data. The number 0 indicates no black pixels in the related area.

We performed three ways to divide the image to find its IoC characteristics, which are divided into 3 × 3, 4 × 4 and 5 × 5. So the number of results from this feature extraction depends on the number of IoC dimensions. IoC 3 × 3 size will produce nine feature data, IoC 4 × 4 will have 16 features, and IoC 5 × 5 will make 25 image feature columns.



(a)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 20 | 24 | 27 | 58 | 15 | 21 | 30 |

(b)

| Horizontal | Vertical | Left Diagonal | Right Diagonal |
|---|---|---|---|
| 0 | 6 | 0 | 0 |
| 0 | 1 | 2 | 6 |
| 0 | 1 | 2 | 5 |
| 0 | 2 | 28 | 0 |
| 0 | 5 | 1 | 0 |
| 0 | 1 | 0 | 1 |
| 0 | 1 | 0 | 18 |
| 0 | 0 | 3 | 1 |
| 2 | 15 | 2 | 0 |

(c)

**FIGURE 3.** To (a) Illustration 3×3 windowing, (b) The pixel value of IoC results in the form of a 1-dimensional vector, (c) The pixel value of MD results

The Mark Direction or MD feature is characterized by counting the number of pixels in the image that have neighbours in the horizontal, vertical, and diagonal directions to the left and the right. Figure 3 (c) is an example of the results of the MD calculation on the image in Fig. 3 (a) for each image area divided into 3×3. Then some 9×4 data

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will be found that describes the total number of pixels that meet the MD neighbours in the nine large areas formed. The image is divided into 4×4 sizes; there will be 16×4, while if the image is divided into 5×5, the features obtained are 25×4.

Nineteen variations of feature utilization were used in the experiment to find traits that contributed to maximum accuracy, as shown in Table 2.

**TABLE 2.** Feature varieties as an input-based variable for ANN

| Experiments | Feature Varieties |
|---|---|
| 1 | Width + height |
| 2 | IoC 3×3 |
| 3 | IoC 4×4 |
| 4 | IoC 5×5 |
| 5 | MD 3×3 |
| 6 | MD 4×4 |
| 7 | MD 5×5 |
| 8 | width + height + IoC 3×3 |
| 9 | width + height + IoC 4×4 |
| 10 | width + height + IoC 5×5 |
| 11 | width + height + MD 3×3 |
| 12 | width + height + MD 4×4 |
| 13 | width + hight + MD 5×5 |
| 14 | width + height + IoC 3×3 + MD 3×3 |
| 15 | width + height + IoC 4×4 + MD 4×4 |
| 16 | width + height + IoC 5×5 + MD 5×5 |
| 17 | width + height + IoC 3×3 + MD 3×3 |
| 18 | width + height + IoC 4×4 + MD 4×4 |
| 19 | width + height + IoC 5×5 + MD 5×5 |

When all the features are generated, combining features is carried out according to the featured scenario used in 1 vector. The z-score normalization process has undertaken the features that have been converted into vectors using the built-in Matlab the mapstd() function.

## Transliteration

The last process is transliteration. When all the extracted features and image normalization are obtained, the feature data will be input into the ANN algorithm to create a predictive model. The resulting output will be a Balinese script label from the input image. The network architecture used in the training and testing process is a backpropagation architecture with one and two hidden layers. In each network architecture, experiments will be done with changes in the combination of variations in the number of neurons in the hidden layer.

The input layer's variables are the feature values used in each experiment. If the first feature variation is used, as shown in Table 2, then the number of input n is only 2, each containing the value of the width and height of the input image. The variables in the hidden layer are used to change the input value into a specific value that can be processed into the output layer and become an index for classification. In this layer, some neurons are applied, such as 10, 15, 20, 35, 40, 45, 50, 55, 60, 65, and 70. For example, if the number of neurons is 20, the variable Z will be 20, from $Z_1$ to $Z_{20}$. The expected combination of hidden layers and neurons could obtain the best accuracy. The Output Layer consisted of 18 neurons, according to the number of Balinese scripts. The target in the output layer will be represented by binary values 0 and 1. The value closest to 1 is the result of the classification.

The newff() function library is used in ANN implementation. The function has three to ten parameters, which we have determined using five. The first parameter is input, which varies from at least 2 data, namely when the 1st feature is applied and a maximum of 127 inputs when the 19th feature is used. The second parameter is the Target. The third parameter is the size of the hidden layer. For example, if the size is [10 5], the first hidden layer has ten nodes, and the second has five nodes. The fourth parameter is the activation function. We used the default values, namely the tansig function, which implements the bipolar sigmoid activation function, and logsig, which implements the binary



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sigmoid activation function. The last parameter is the learning method. In our experiment, we applied the variations of trainlm, traingdx and trainscg methods. The trainlm method is the Levenberg-Marquardt algorithm as the default learning method. Other training methods are traingdx, which applies the Gradient Descent algorithm with Momentum and Adaptive Learning Rate, and the trainscg, which is a network training function using the scaled conjugate gradient method.

## EXPERIMENT RESULT AND ANALYSIS

The 1001 Balinese script image data segmentation from palm leaf images has been tested. First, we divided the dataset by 80% of the training data and 20% of the test data for each character image from 18 types. The preprocessing stage has five critical processes to prepare the data for feature extraction, from converting an RGB image to thinning image processing. Figure 4 (left side) shows a picture of the original image, which was initially 35×51 pixels in size with data type uint8. After preprocessing, it becomes a new image thinner and measures 60×60 with the logical data type (right side).

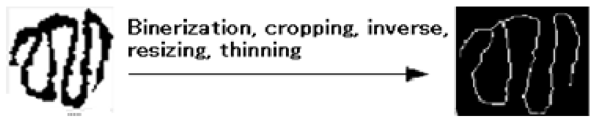


**FIGURE 4**. Image description before and after processing in the preprocessing stage

At the feature extraction stage, after the data has been subjected to the preprocessing process, it will continue to obtain features from the image. The features of each image are then converted into a 1 × n matrix. The value of n depends on the type of feature used in the experiment, as shown in Table 2. The test is carried out to get the optimal network architecture using several parameter combinations. The first parameter is the variation of the logsig and tansig activation functions, then the variation in the number of neurons 20, 25, 30, 35, 40, 45, 50, 55, 60, 65 and 70, and the variation in the number of hidden layers 1 and 2, and the input variation as shown in Table 2, and various learning functions trainlm, traingdx and trainscg.

The first experiment was applied to 2 inputs, length and width features of the image, as well as with one hidden layer (Table 2 experiment 1). The accuracy for these variables can be seen in Table 3 below.

**TABLE 3.** The accuracy of length and width features on 1 hidden layer

| Number of Node | Learning traimlm | | Learning traingdx | | Learning trainscg | |
|---|---|---|---|---|---|---|
| | Activation | | Activation | | Activation | |
| | Logsig | tansig | Logsig | Logsig | Logsig | Logsig |
| 20 | 31.63 | 39.80 | 37.24 | 25.00 | 35.20 | 31.12 |
| 25 | 40.82 | 35.20 | 28.06 | 30.61 | 38.27 | 35.20 |
| 30 | 34.18 | 37.24 | 32.65 | 28.06 | 34.69 | 32.65 |
| 35 | 36.73 | 40.82 | 36.73 | 33.67 | 35.71 | 38.27 |
| 40 | 41.33 | 40.31 | 33.67 | 33.67 | 33.16 | 37.76 |
| 45 | 35.71 | 43.37 | 32.65 | 33.67 | 35.71 | 36.22 |
| 50 | 36.73 | 39.29 | 28.57 | 27.04 | 36.22 | 38.78 |
| 55 | 37.24 | 40.31 | 27.55 | 29.08 | 33.16 | 35.20 |
| 60 | 36.73 | 41.84 | 29.59 | 31.12 | 37.76 | 32.14 |
| 65 | 38.78 | 36.22 | 34.69 | 26.02 | 34.18 | 38.78 |
| 70 | 34.18 | 37.24 | 30.10 | 23.47 | 38.27 | 37.24 |

The highest accuracy in the first test is 43.37% with the parameter: the number of nodes is 45, the learning function is trainlm, and the activation function is tansig. The same test is then carried out by adding one more hidden layer, where the parameters in layer 1 are 45 nodes, as shown in Table 4.

From the test scenario using Feature 1 (length and width) as shown in Table 3 and then continued to Table 4, the highest accuracy is 44.39%. The parameters were applied, the learning function was trainlm, and the activation function was logsig with the number of nodes being 45 and 40 for hidden layer one and hidden layer 2, respectively.

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**TABLE 4.** The accuracy of length and width features with two hidden layers and the node is 45 in the first hidden layer

| Number of Nodes | Learning traimlm | | Learning traingdx | | Learning trainscg | |
|---|---|---|---|---|---|---|
| | Activation | | Activation | | Activation | |
| | Logsig | tansig | Logsig | Logsig | Logsig | Logsig |
| 20 | 39.29 | 35.20 | 33.67 | 35.20 | 37.24 | 21.43 |
| 25 | 35.71 | 37.24 | 25.00 | 35.20 | 39.29 | 38.78 |
| 30 | 38.27 | 42.35 | 28.57 | 33.16 | 30.61 | 30.61 |
| 35 | 38.27 | 37.76 | 26.02 | 37.76 | 27.55 | 40.82 |
| 40 | 44.39 | 39.80 | 36.22 | 37.76 | 34.69 | 29.59 |
| 45 | 37.24 | 40.82 | 35.20 | 37.24 | 29.59 | 33.67 |
| 50 | 37.24 | 36.22 | 36.22 | 33.67 | 33.16 | 33.16 |
| 55 | 35.71 | 40.31 | 30.61 | 34.18 | 38.27 | 34.69 |
| 60 | 41.33 | 35.20 | 30.61 | 35.20 | 37.76 | 37.76 |
| 65 | 41.84 | 39.29 | 26.53 | 28.57 | 31.63 | 35.71 |
| 70 | 35.71 | 40.82 | 31.12 | 37.76 | 37.76 | 38.27 |

The use of a parameter that delivers the highest accuracy would be applied to other experiments (see. Table 2). The first test scenario for Feature 1 is then applied to all the characteristics that have been determined as in Table 1. A summary of the best accuracy for the entire experiment can be seen in Table 5.

**TABLE 5.** Summary of parameters in the best accuracy obtained in each test scenario

| Experiment | Number of Neurons | | Activation Function | Learning Function | Accuracy (%) |
|---|---|---|---|---|---|
| | Layer 1 | Layer 2 | | | |
| 1 | 45 | 40 | Logsig | Trainlm | 44.39 |
| 2 | 50 | 50 | Logsig | Trainlm | 80.61 |
| 3 | 60 | 65 | Logsig | Trainscg | 86.22 |
| 4 | 50 | 25 | Tansig | Trainscg | 89.28 |
| 5 | 40 | 70 | Logsig | Trainscg | 85.71 |
| 5 | 70 | 55 - 65 | Tansig | Trainscg | 84.18 |
| 7 | 65 | 50 | Tansig | Trainscg | 87.24 |
| 8 | 55 | 70 | Tansig | Trainscg | 85.71 |
| 9 | 40 | 55 - 65 | Tansig - Logsig | Trainlm | 85.71 |
| 10 | 50 | 40 | Tansig | Trainscg | 87.76 |
| 11 | 55 | 70 | Logsig | Trainscg | 88.27 |
| 12 | 45 | 55 | Tansig | Trainscg | 87.76 |
| 13 | 30 | 25 | Tansig | Trainscg | 87.76 |
| 14 | 65 | 50 | Logsig | Trainscg | 87.24 |
| 15 | 45 | 45 | Tansig | Trainscg | 90.31 |
| 16 | 70 | 40 | Tansig | Trainscg | 90.31 |
| 17 | 50 | 55 - 65 | Logsig - Tansig | Trainscg | 88.78 |
| 18 | 70 | 45 | Logsig | Trainscg | 89.80 |
| 19 | 70 | 20 | Tansig | Trainscg | 89.29 |

The test results show that the trainlm training method gets optimal performance on networks with one hidden layer, while trainscg gets optimal performance on networks with two hidden layers. In contrast, traingdx does not get the best results anywhere. When doing model training, the fastest time of training when using traingdx, then trainscg and the longest trainlm. Our results are similar to Indyaputra's study [9], when conducting research using the trainlm and traingdx training methods, where the best accuracy is obtained using the trainlm method. However, it is slightly different from Wibowo [10] when testing with the traingdx, traingda and trainrp training methods. The traingdx parameter provides the best accuracy in several traits. After conducting experiments and comparing with previous

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research, from the training methods trainlm, traingdx and trainscg, trainscg has the best performance compared to other training methods with the most significant number of best accuracy of 24.

The test also performs a combination of activation methods, namely logsig with tansig, which is tested into various features and 1 and 2 hidden layers. The Tansig activation method can provide optimal performance using two layers, while Logsig is suitable for one layer. The Tansig activation method and the Trainscg training method with a two-layer network configuration delivered the best experimental accuracy.

The most significant classification error was in the predictions of "ta" and "ha" scripts, with a total error of 3. Prediction of the script "ta" got two errors, predicting the script 'ta' as the script "ha". The similarity of shape between the two scripts caused the error. The image quality becomes the main factor. The image quality for testing was not as good as other scripts, as shown in Fig. 5.

**FIGURE 5.** The similarity between "ta" and "ha" scripts

Several other images did not find any errors during testing, such as 'sa', 'ma', 'koma', 'tedong', 'wa', 'ya/pangkon', 'suku' and 'mangka' scripts. The results are good because the image data are pretty different from others and have a good test image quality. So, when the image is subjected to preprocessing, good image quality results are obtained.

## Single Data Test

We continued the experiment by testing a single data for 1 data on each type of character that had not been used in previous experiments. The combination of 15 features, namely IOC and MD measuring 4 × 4, was used as input to the optimal network architecture. A summary of the experiment is in Table 6 below.

**TABLE 6.** A summary experiment in the single data test

| Experiments | Script Source | Script Target | Description |
|---|---|---|---|
| 1 | ha | Wa | False |
| 2 | ta | Ta | True |
| 3 | pa | Pa | True |
| 4 | sa | Sa | True |
| 5 | ma | Ma | True |
| 6 | ka | Ka | True |
| 7 | nga | Nga | True |
| 8 | koma | Koma | True |
| 9 | ulu | Ulu | True |
| 10 | tedong | Tedong | True |
| 11 | na | Na | True |
| 12 | da | Da | True |
| 13 | wa | Wa | True |
| 14 | taleng | Taleng | True |
| 15 | ra | Ra | True |
| 16 | Ya | Ya | True |
| 17 | suku | Suku | True |
| 18 | Ngka | Ngka | True |

The single dataset experiment shows that 94% accuracy was obtained by implementing our predictive model. Minimizing mistakes should be done by eliminating some images with poor quality and adding new images with good quality. In this case, the script 'ha' predicted to 'wa'.

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## CONCLUSION

More and more people are abandoning local scripts because they are challenging to learn, and most of them are starting to break or become blurry. This study shows that machine learning approaches using an ANN algorithm can be used to recognize or predict the Balinese script on lontar leaves. The predictive model could predict the scripts with the accuracy of 90.31% for dataset training and 94% for dataset testing. Our study also shows that selecting machine learning parameters and eliminating poor image quality will minimize prediction errors. Another factor that also influences is the firmness of the script lines so that it is easy to be used to distinguish one image from another. This makes the training process provide a good predictive model.

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