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Ngaksara: A Mobile Application for Javanese Script Writing Learning and Assessment Media

Nurizal Dwi Priandani[1], Nimas Ratna Sari[2], Komang Candra Brata[3]

[1*]Informatics Engineering, Faculty of Science and Technology, UIN Maulana Malik Ibrahim, Malang, Indonesia
[2]Information Technology, Faculty of Business and Technology, ITSK Sugeng Hartono, Sukoharjo, Indonesia
[3]Department of Information and Communication Systems, Okayama University, Okayama 700-8530, Japan
[1*]nd.priandani@uin-malang.ac.id, [2] nimasratna@sugenghartono.ac.id, [3] k.candra.brata@ub.ac.id
*Corresponding author

***Abstract*--Javanese script writing learning was still faced with limited interactive media and delayed assessment feedback in conventional classroom practices. An interactive mobile learning and assessment medium was therefore developed and named the Ngaksara mobile application. A canvas-based Android interface was provided to allow learners to write Javanese characters directly on the touchscreen. Handwritten input was processed through preprocessing and template matching stages, and the similarity between the input image and the standard character template was measured using Manhattan Distance. The assessment result was then converted into a learning category and displayed as immediate feedback for learners. The application used 80 expert-written Javanese character templates as reference templates, while 30 learner handwriting samples were used as evaluation data to assess the agreement between the system output and expert judgment. The system output was highly consistent with expert assessment, and a high level of accuracy was obtained in the handwriting evaluation process. The proposed application was therefore considered useful for supporting Javanese script writing practice and assessment. A simple and lightweight computational approach was also demonstrated, making the application practical for mobile-based educational implementation.**

***Key words*: Education; Handwriting; Javanese script; Learning; Mobile apps.**

I. INTRODUCTION

The island of Java, Indonesia, is a famous place with a rich history of culture. This cultural wealth is one of the priceless historical heritages that holds many historical artifacts, including traditional Javanese chronicles, philosophy of life, art, types of literature, and ancient texts written in Javanese script [1][2]. The main challenge to preserving this culture is the lack of participation of Indonesia's younger generation to actively preserve this culture as part of the ancestral heritage of the Javanese people. In this case, the Indonesian government has set rules to make local content subjects compulsory at the elementary to junior high school levels to maintain this culture.

The content of this local subject can be adapted from each regional culture where the school is located. The aspect of local content that is widely taught, especially in the regions of East Java, Central Java, and Special Region of Yogyakarta, is the Javanese language. The Javanese language lesson covers four essential language abilities: reading, listening, speaking, and writing skills. The learners find listening and speaking skills less challenging since they still use the Javanese language in their daily activities. However, for reading and writing, the learners need to put more effort since they have to recognize the Javanese script, where the letters used are very different from the Latin letters commonly used by Indonesian people.

The use of Javanese script has decreased very sharply since the Japanese colonial period in Indonesia until now. At this time, Javanese script is only found in certain places, such as temples, historical relics, historical sites, and special places managed by the local government. Therefore, Javanese script which include in Javanese language course, is widely taught in the regions of East Java, Central Java, and Special Region of Yogyakarta. However, the major limitation of learning Javanese script is the method itself [3]. Almost all local content teachers only teach reading and writing Javanese texts through lectures [4]. This conventional Javanese script learning media makes the educational process uninteresting to the students. This makes it difficult for the younger generation to understand Javanese texts.

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Along with technological developments, mobile apps have been able to simplify activities in human life. Research in developing mobile apps has been carried out in several other cases, including Mobile Culinary Recommendation System Based On Group Decision Support System [5], Mobile Application of Beef Image Classification for Quality Identification [6], and Malang historical tourism guide mobile application based on geolocation [7]. In other words, mobile apps can be an option for developing Javanese script learning tools that are more interesting and interactive for students. Interesting is a state of enjoyment, while interactive is the student's quick response from the system [8]. The conventional method used by the students to learn Javanese scripts is by incorporating consonants and vowels into one syllable in one character [9]. Similarly, students solely consider how their writing is readable, regardless of the standard of correctness. Before the teacher examines their work, the students do not know whether their writing is correct.

Based on these issues, this study develops Ngaksara, an Android-based mobile application for Javanese script writing learning and assessment. The application provides a canvas-based interface that enables learners to select a Javanese character, write it directly on the touchscreen, and obtain immediate assessment feedback. The proposed system applies image preprocessing and template matching to compare the learner's handwriting with standard Javanese script templates. Manhattan Distance is used to measure the difference between the input image and the reference template. The result is then converted into an assessment category to help learners understand the quality of their writing.

The main contribution of this study is the development of a simple and lightweight mobile learning medium that integrates Javanese script writing practice with automatic assessment feedback. Unlike recognition systems that only identify characters, the proposed application is designed to support the learning process by evaluating handwriting similarity and presenting the result directly to users. The use of template matching also supports practical mobile implementation because it does not require intensive training computation. Therefore, Ngaksara is expected to provide an interactive, accessible, and efficient learning medium for Javanese script writing practice.

II. Related Works

Several previous works have been conducted on Javanese script character recognition. Mahastama and Krisnawati performed segmentation and classification of Javanese script in a printed document [10]. The segmentation method showed a positive result. However, Mahastama and Krisnawati argue that the classification task could be improved. In addition, several neural network models have been used to recognize Javanese scripts in handwritten form. This model varies from a twelve-layer deep convolutional neural network (DCNN) and SoftMax classifiers [11] to a convolutional neural network (CNN) [12]. An advanced system for handwritten Javanese character recognition has been developed by a study [13] employing various artificial neural network techniques. Pre-processing techniques were employed to recognize Javanese characters in the study [14], particularly feature extraction using the Histogram Chain Code (HCC) method and classification using artificial neural networks utilizing the Multi-Layer Perceptron method. Zoning feature extraction is used in research [15] to recognize handwritten Javanese characters. According to a study [16], Javanese characters may be recognized by their roundness and eccentric features. Study [17] employed the Connected Component Labeling method, which is applied as an algorithm used to detect linked blob areas in a binary image, to segment Javanese script in the old manuscript. These models obtain excellent Javanese script recognition results to be applied to other systems, even though neural networks are famous for their processes, which require a lot of computational power.

A template matching method has been used to introduce Javanese script in [18], [19], and [20]. Based on the study of [19] and [20], an application was created to detect Javanese writing letters using optical character recognition (OCR) with a template matching method. While Study [19] assesses student handwriting of Javanese script.

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In previous research, Javanese script character recognition was developed on the Android smartphone platform. According to research [21], Javanese script is recognized using the $P method employing cross-validation and a micro- and macro-average assessment measure rule. Using Unity Engine, a touchscreen Android application was created. In order to gather datasets for OCR in Javanese characters, research [22] built optical character recognition using Tesseract with the Javanese script target in an Android application.

III. METHOD

In this section, a brief description of the design of the algorithm used in the application and its implementation on an Android platform device is provided. Additionally, the process of gathering and using data in this work is discussed.

A. System Design

Fig. 1 illustrates the application flow process design. Initially, the user selects a Javanese script which they want to learn. Then, a canvas will appear in which they can write the character they have chosen. The user's handwriting is then compared with the template prepared in the form of an image once the user selects the process button. The method proposed by Priandani et al. [19] is employed in the image processing phase, which begins with the preprocessing stage and proceeds to the similarity distance measurement stage.

The preprocessing stage aims to handle image variations in both training and test data, which may have varying sizes due to users writing characters of different sizes although the screen size might be the same. To address this, each image is resized to maintain the same character size. Then, Direct Matching is a technique used to compute the binary input data in the form of an interpixel basis, represented by a matrix. Direct Matching produces similarities or dissimilarities between test and training data. In this process, similarity measurement is conducted using the Manhattan Distance metric.

The user input entries, referred to as test data, were compared with the training data. Following the previous stage where dissimilarities were obtained, a rating rule was applied. The evaluation formula for each Javanese script character is expressed in Equation (1).

$$Score = \frac{Dissimilarity}{Total\ number\ of\ Pixel}\ x\ 100 \qquad (1)$$

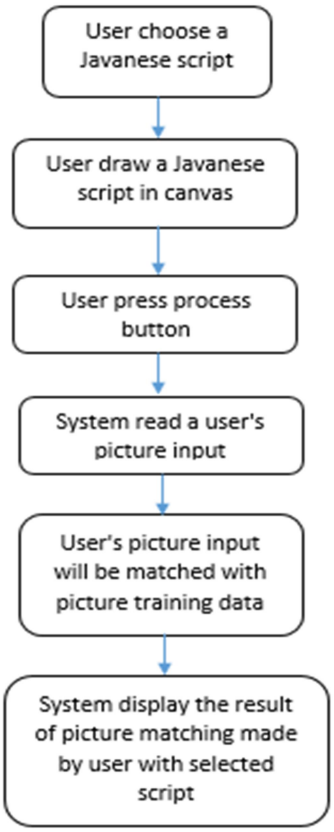

Fig. 1. Application flow process

In the implementation process, Equation (1) was implemented using a fixed variable of pixel size; 100 x 100 pixels. In addition, by substituting the dissimilarity function with the total number of pixels minus similarity. This resulted in Equation (2).

$$Score = \frac{(100\ x\ 100) - similarity}{(100\ x\ 100)}\ x\ 100 \qquad (2)$$

Once the similarity score is obtained, it is converted into the scale supplied in Table 1. This process converts the score into five categories, each with the same range of values. The conversion values of the figures obtained in the test using the Likert scale are used to determine the five assessment ranges. At the end of the phase, the matching result value will be displayed by the application.

B. Data

In this study, two types of data were used: the reference template dataset and the evaluation dataset. The reference template dataset was used as the standard comparison data in the template matching process. It was not used for model

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training because the proposed method does not involve a machine learning training process. Instead, the system compares each learner's handwriting input with predefined expert-written templates.

TABLE I
Conversion Value Scale

Scale	Score Range
Excellent	81 – 100
Very Good	61 – 80
Good	41 – 60
Fair	21 – 40
Poor	0 – 20

As stated by Priandani et al. [19], the application contains hand-writing Javanese character data obtained from the expert (teacher) as the writing standard. The reference template dataset consisted of 80 Javanese character images obtained from an expert teacher. These templates represented 20 basic Javanese carakan characters, with four writing variations for each character: upright, erect-thick, oblique, and oblique-thick, as shown in Fig. 2 - 5. These templates were stored as application assets and used as standard patterns during the matching process.

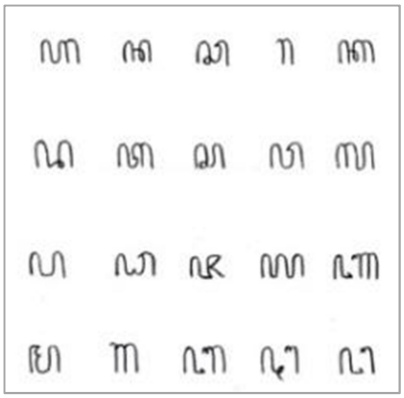

Fig. 2. Upright character

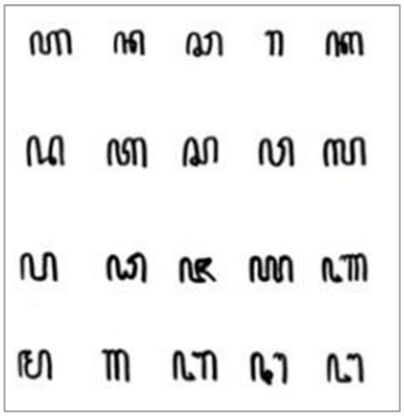

Fig. 3. Erect-thick character

Fig. 4. Oblique character

Fig. 5. Oblique-thick character

The evaluation dataset consisted of learner handwriting samples collected through the Android application canvas. Each sample was written directly on the smartphone touchscreen and processed by the system after the user pressed the process button. These handwriting samples were used only for evaluating the system output by comparing the assessment category generated by the application with the assessment category given by the expert.

IV. Result and Discussion

This section provides an explanation of research implementation, experiment setup, and outcomes. The main objective of this research is to assess the accuracy of the application and compare it with the expert assessment results.

A. Implementation

An Android application named Ngaksara has been created to incorporate our proposed method, which aims to provide interactive learning media. Ngaksara is a mobile application on the Android platform that allows users or students to learn Javanese script writing using a touch screen with canvas. The application includes training data as an asset, and in the last process, the result score is shown in the form of a converted likert scale. Fig. 6 - 9 displays a screenshot of Ngaksara Apps.

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Fig. 6. The main landing page with a "Mulai" (Start) button

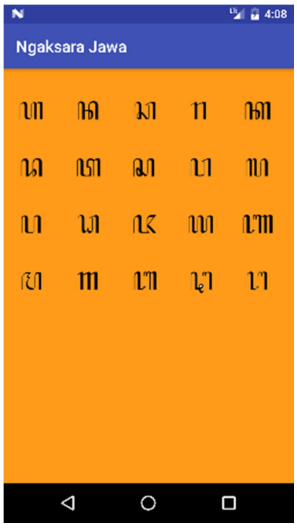

Fig. 7. Twenty basic Javanese Carakan characters

Fig. 8. The canvas interface for character writing practice

B. Experiment Setup

The experiment was conducted by comparing the system's output with the assessment made by a Java language teacher, who served as an expert. To obtain the accuracy results, the number of correct answers was divided by the total number of data. Any result that differed from the expert's judgment was considered invalid. The accuracy experiment was conducted using a smartphone with a 5-inch screen to write the script, and the system calculated the results.

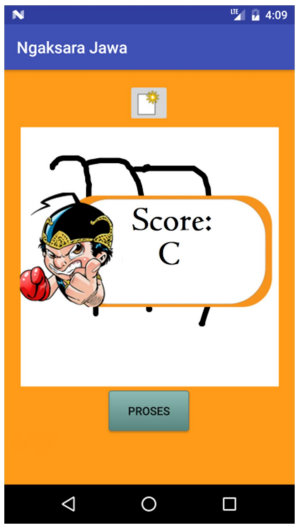

Fig. 9. The assessment results screen

The learner handwriting samples used in the experiment were separated from the reference template dataset. The 80 expert-written templates were used only as reference patterns in the template matching process, whereas the learner handwriting samples were used only for evaluation. Therefore, the accuracy value represents the agreement between the system-generated assessment and expert assessment of unseen learner handwriting samples.

C. Experiment Results

The evaluation process involved comparing the scores generated by the application with those obtained through manual assessment. A total of 30 learner handwriting samples were used as the evaluation dataset in the initial experiment. These samples were independent of the 80 expert-written reference templates used by the application. The results are presented in Table 2, which shows the accuracy test outcomes. According to it, the application was able to produce valid results in 29 out of 30 test cases, resulting in an accuracy rate of 96.67% when compared to manual assessment. This indicates that the application's assessment has a high level of accuracy.

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TABLE II
Accuracy Result

No	Test Value		Result
	System	Expert	
1	Very Good	Very Good	Matched
2	Very Good	Very Good	Matched
3	Very Good	Very Good	Matched
4	Very Good	Very Good	Matched
5	Very Good	Very Good	Matched
6	Very Good	Very Good	Matched
7	Very Good	Very Good	Matched
8	Very Good	Very Good	Matched
9	Very Good	Very Good	Matched
10	Very Good	Very Good	Matched
11	Very Good	Very Good	Matched
12	Very Good	Very Good	Matched
13	Very Good	Very Good	Matched
14	Very Good	Very Good	Matched
15	Very Good	Good	Unmatched
16	Very Good	Very Good	Matched
17	Very Good	Very Good	Matched
18	Very Good	Very Good	Matched
19	Very Good	Very Good	Matched
20	Very Good	Very Good	Matched
21	Very Good	Very Good	Matched
22	Very Good	Very Good	Matched
23	Very Good	Very Good	Matched
24	Very Good	Very Good	Matched
25	Very Good	Very Good	Matched
26	Very Good	Very Good	Matched
27	Very Good	Very Good	Matched
28	Very Good	Very Good	Matched
29	Very Good	Very Good	Matched
30	Very Good	Very Good	Matched

D. Discussion

An interactive medium for Javanese script writing practice and assessment was developed and named the Ngaksara mobile application. A digital canvas was provided in the application on an Android device. Selected Javanese characters were displayed to guide learners during the writing practice. Handwritten input was produced by the student through direct interaction with the touchscreen canvas. The input image was captured and processed by the system after the process button was selected. An assessment result was displayed immediately after the matching process was completed. Direct feedback was provided through this mechanism during the learning activity. The dependence on delayed manual correction by the teacher was therefore reduced.

The template matching algorithm was employed as the main assessment method in the application. Each handwriting input was compared with a standard Javanese script template stored in the application assets. The input image was standardized before the comparison process was conducted. Variations in character size and writing form were minimized through the preprocessing stage. The dissimilarity between the input image and the reference template was calculated using the Manhattan Distance. The assessment category was generated from the similarity result. The system output was generally consistent with expert judgment. The suitability of template matching for structured Javanese handwriting assessment was therefore indicated.

A lightweight computational approach was demonstrated using template matching in the mobile application. Direct image comparison was applied instead of complex feature learning. Intensive training processes commonly required in deep learning-based methods were avoided. Simpler computation was required during the handwriting assessment process. The application was made more practical for smartphone-based deployment through this algorithmic characteristic. Fast response, low resource usage, and easier implementation were supported in the educational context. Useful assessment support for Javanese script handwriting learning was provided through a simple and lightweight image matching approach.

V. CONCLUSION

An interactive mobile learning and assessment medium for Javanese script handwriting was developed and named the Ngaksara mobile application. A canvas-based Android interface was provided to allow learners to practice writing Javanese characters directly on the touchscreen. Handwritten input was processed through preprocessing and template matching stages before the assessment result was generated. The similarity between learner handwriting and standard Javanese script templates was measured using Manhattan Distance. The assessment category was then displayed as immediate feedback for learners. The system output was generally consistent with expert judgment, so the proposed application was considered useful for supporting Javanese script writing practice. A simple and lightweight computational approach was also demonstrated using template matching, making the application practical for mobile-based

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educational implementation.

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