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Javanese character recognition based on k-nearest neighbor and linear binary pattern features

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Abstract
Javanese script (Hanacaraka) is one of the cultures owned by Indonesia. Javanese script is found in temples, inscriptions, cultural and prehistoric sites, ancient Javanese manuscripts, Gulden series banknotes, street signage, and palace documents. Javanese script has a form with an article, and the use of reading above the script is a factor that affects the character detection process. Punctuation marks, clothing, Swara script, vowels, and consonants are parts of the script that are often found in Javanetest scripts. Preserving Javanese script in the digital era, of course, must use technology that can support the digitization of Javanese script through the script detection process. The concept of script image is the image of Javanese script in ancient manuscripts. The process of character detection using certain techniques can be carried out to extract characters so that they can be read. Detection of Javanese characters can be found by finding a testing image. Here, we had been used 10 words images consisting of 3 to 5 syllables with the vowel aiu. Dataset process by Linear Binary Pattern (LBP) feature extraction, which is used to characterize images and describe image textures locally. LBP has been used in r=4 and preprocessing is also done by thresholding with d=0.3. This process can be done using the K-Nearest Neighbor algorithm. In 10 datasets of Javanese script words, an average accuracy value of 90.5% was obtained. The accuracy value of 100% is the highest and 50% is the lowest.

1. Introduction

Indonesia has cultural diversity and is rich in languages. One of the Indonesian cultural heritages that developed on the island of Java is the Javanese script. Javanese script or better known as Hanacaraka is often used to write literature and daily writing in Javanese from the mid-15th century to the mid-20th century, but over time it is also used to write in various regional languages. Javanese script has written in the form of letters [1][2][3][4]. Along with the development of the times, Javanese script seems to be forgotten and rarely recognized by the public, especially the younger generation today. However, the Javanese script is still taught in schools in various areas on the island of Java, such as Yogyakarta, Central Java, East Java, and some areas in West Java, as part of the learning curriculum with limited application in everyday life. However, it is not uncommon to find Javanese script writings in certain places, such as tourist attractions, schools, government agency boards, and street signage. As a young generation, preserving Javanese script writing culture, especially on the island of Java, is very important so that it remains known to the next generation.

One of the factors that make Javanese script difficult to recognize is because it has a difficult form and has complicated elements found in Javanese script. The fact is so. The current Javanese script is no longer widely recognized, even by the younger generation of Indonesia. If it is not done with the right method, learning the Javanese script is very difficult because the script is more complicated than the Latin script which is studied and used every day to communicate [5][6][7][8]. From these problems, it is necessary to have a process of preserving the Javanese script so that it can be re-interested, especially by the younger generation. In this study, it has been used as an effort to learn while preserving Javanese culture, especially Javanese script, by transliterating Javanese script into Latin writing. In addition to being able to transliterate, this can also help in understanding and learning Javanese script letters.

Image Processing was developed to improve or improve image quality that is better than before. One of the methods in image processing is Thresholding [9][10][11]. Thresholding is one of the methods for segmenting the image which in the procedure is based on the contrast at the gray level of the image. The dark areas of the image will be made darker, while the light areas of the image will be made lighter. The output of the thresholding segmentation process [12] is a binary image with a pixel value of 0 or 1. The pixel intensity value is 0 for perfect black and 1 for perfect white. This method will be used to separate the Java script image object from its background. Optical Character Recognition (OCR)

is a technology that can assist in scanning images. By utilizing OCR, it will be able to assist in the process of converting images containing Javanese script writing which will later be transliterated.

Some image classification algorithms that are often used are K-Nearest Neighbor (K-NN), Principal Component Analysis (PCA), K-Means, Fuzzy C-Means (FCM), and Support Vector Machine (SVM). The K-Nearest Neighbor (KNN) algorithm [13][14][15] is a method for carrying out the object classification process where the results of a new object sample are taken based on the majority of which are close to the old object in question. The purpose of the K-Nearest Neighbor (KNN) algorithm is to classify new objects based on characteristics and training data. The K-Nearest Neighbor (KNN) algorithm performs the work process based on the shortest distance from the new object data to the old object data to determine the KNN value as the predictive value of the new sample (instance) value. After being found based on the similarity value, then the value is then grouped based on certain classes. The Euclidean Distance method is used to determine the shortest and farthest distances. The way the K-Nearest Neighbor (KNN) algorithm works is to determine the value of k as a class determinant, calculate the distance to each object in the training data using the Euclidean Distance method and take the number of k values with the closest distance which then sorts the results from the calculation of the similarity value from smallest to largest. Because K-Nearest Neighbor (KNN) is classified as having a simple concept, the use of the K-Nearest Neighbor (KNN) algorithm is very popularly used to solve problems in image processing such as object recognition, pattern recognition, and text grouping.

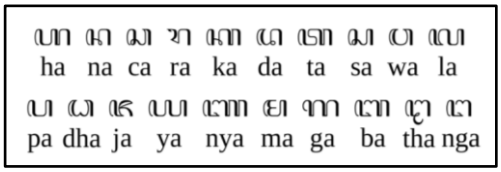
2. Related Research

Khadijah [16] conducted research on the recognition of Javanese script writing and used a total dataset of 2470 samples divided into 20 classes, with each class containing 123 data samples. The method used is Convolutional Neural Network and Deep Neural Network and then the results of the accuracy of the two methods are compared. The results show that the accuracy of the Deep Neural Network is lower than that of the Convolutional Neural Network, which is 64.41% using 2 hidden layers. While the best accuracy results obtained from the use of the Convolutional Neural Network Method is 70.22% using one layer of convolution with 20 filters. The conclusion obtained is that the Convolutional Neural Network Method is an algorithm that produces the best results for classifying locally correlated data. Sari [17] researched the classification of handwritten Javanese characters using the K-Nearest Neighbor Algorithm as the identification classification method. While the feature extraction used is a combination of Roundness and Eccentricity Feature Extraction. As many as 240 handwritten Javanese characters are used as a dataset which is divided into Training Data of 200 data, and Test Data of 40 data. In this study, the results obtained an accuracy of 87.50%, where from this accuracy it can be concluded that the KNN Classification Method can provide good performance results related to handwriting recognition of Javanese script. Another research by [18] using a template matching algorithm proposed Optical Character Recognition (OCR) and Matching Correlation Method. Based on 20 datasets for each character, the results obtained are 93.44% accuracy with an error rate of 6.56%. In this study, the dataset needs to be added, and preprocessing needs to be done to clean the image. In [19] classification to recognize Javanese script characters, using K-Nearest Neighbor (K-NN), Linear Discriminant Analysis (LDA), Support Vector Machine (SVM), and Gaussian Naive Bayes to obtain accuracy which is then compared. based on the results of the comparison between the methods used, the results show that K-NN produces the best accuracy results with an accuracy value of 0.71 on Weighted-averaged Precision and 0.69 on Weighted-averaged Sensitivity. Research by [20], examined the use of the Texture Feature Local Binary Pattern and the K-Nearest Neighbor Algorithm as a classification algorithm for recognizing handwritten characters. By using parameter [3 3] in a 5x5 grid for LBP and parameter k = 3 for KNN, the results obtained are 90.99% accuracy. From the accuracy results, it was concluded that the method used produced a good performance. Another Javanese script research by [21], related the use of the Backpropagation Method with Zoning Feature Extraction to recognize Javanese script handwriting. A dataset of 600 image data is used which is then processed by gray scaling, binarization, noise removal, crop edge, and resizing. This study also used a network architecture consisting of 64 input neurons, 40 hidden neurons, 0.003 learning speed, 0.03 momentum, and 5000 iterations which then resulted in the highest accuracy value of 77%.

3. Research Method

3.1 Javanese Script (Hanacaraka)

Javanese script (Hanacaraka) is one of the cultural heritages in Indonesia that developed on the island of Java. Javanese script Carakan or basic script consists of 20 pieces. Javanese script also has clothing that is used to provide vocal pronunciations for Basic Script, Murda Script, Swara Script, Partner Script, and Wilangan or Javanese Numerals [21] as shown in Figure 1.



(a)

Nama Sandhangan	Aksara Jawa	Keterangan	Nama Sandhangan	Aksara Jawa	Keterangan
Wulu	ꦶ	tanda vokal i	Wignyan	ꦃ	tanda ganti konsonan h
Suku	ꦸ	tanda vokal u	Cecak	ꦂ	tanda ganti konsonan ng
Taling	ꦺ	tanda vokal é	Pangkon	ꦿ	tanda penghilang vokal
Pepet	ꦼ	tanda vokal e	Péngkal	ꦾ	tanda ganti konsonan ya
Taling Tarung	ꦺꦴ	tanda vokal o	Cakra	ꦽ	tanda ganti konsonan ra
Layar	ꦽ	tanda ganti konsonan r	Cakra keret	ꦽꦼ	tanda ganti konsonan re

(b)

Figure 1. (a) Carakan Javanese Script or Basic Javanese Script, (b) Sandhangan for Javanese Script

From the 15th century until the middle of the 20th century, Javanese script was very actively used by the Javanese people for daily writing and for writing literature [1], [16]. Until now, the Javanese script is still part of the lesson for curriculum development for regional potential development (local content) in various regions including Central Java, Yogyakarta, East Java, and some areas in West Java. Javanese script can also be found in certain places, such as street names to agency boards.

3.2 Digital Image Processing

Image processing is the technique to convert the input image into another image to have an output with better quality than before. Image is a function of light intensity which is represented in a two-dimensional plane. The embodiment of images varies, ranging from still images to moving images. Because image processing is done by computer, the image to be processed is first transformed into discrete quantities from the level of gray values at the point of image elements. This image form is known as a digital image. Image processing [2]–[5] is divided into two types of methods, namely analog image processing, and digital image processing. Analog image processing is an image that is continuous, for example, such as digital cameras, paintings, photographic images, the human eye, and so on. Analog images have quality with a very good level of resolution, but cannot be represented, duplicated, and processed on a computer directly. Digital image processing is an image that can be processed by a computer. Generally, digital images are in the form of rectangles or squares in some imaging systems, some are in the form of a hexagon that has a certain width and height. Represented by pixels (picture elements) which have coordinates x and y as a pointer to the location of pixels in an image, and an amplitude f(x,y) which indicates the value of the color intensity of the image. Image processing is often used to identify objects, improve and improve image quality, object classification, image compression, image segmentation, and pattern recognition.

3.3 Thresholding Segmentation

Image segmentation aims to separate objects from the background so that objects can be easily analyzed. Thresholding is the simplest method for segmenting images. Thresholding [9], [12] operates by dividing the image into two areas, namely the object area and the background area. The pixel intensity value is 0 for perfect black and 1 for perfect white. This method uses a threshold value of T as a benchmark to decide whether a pixel is converted to black or white. The thresholding process is a process to change the quantity in the image, to perform thresholding calculations for gray degrees as in Equation 1.

$$x = b.int\,(\frac{w}{b}) \tag{1}$$

3.4 Linear Binary Pattern (LBP)

LBP is one of the most effective texture extraction features used in supervised learning using both classification and clustering methods. LBP texture analysis [22]–[24] works in local spatial patterns and gray contrast images. LBP works using 3x3 pixel blocks in grayscale images (b) and has a pixel center in the middle (c). Then do thresholding, comparing the pixel intensity between neighboring pixels (8 pixels) with the center pixel (c). In the pixel comparison, the same rules apply as in Equation 2. Where Fc is the grayscale pixel value at the center of the 3x3 pixel block and fp is the grayscale pixel value of each neighboring pixel center. If the neighboring pixels are greater than the center or the same, then the value is 1 and vice versa will be 0 (d). Another advantage of using LBP is its tolerance for changes in illumination (lighting) because the extraction results will remain the same even though there is a change in the light intensity in the image. In addition, simple computing using LBP allows its use in analyzing features in real-time. In this study, LBP has been implemented in r=4.

$$S\left(f_p - f_c\right) = \begin{cases} 1, & f_p \geq f_c \\ 0, & f_p < f_c \end{cases} \quad (2)$$

3.4 K-Nearest Neighbors (K-NN)

The K-Nearest Neighbor (KNN) algorithm is a method for carrying out the object classification process where the results of a new object sample are taken based on the majority of which are close to the old object in question. The purpose of the KNN algorithm [25]–[27] is to classify new objects based on characteristics and training data [14]. The KNN algorithm performs the work process based on the shortest distance from the new object data to the old object data to determine the KNN value as the predictive value of the new instance value. After being found based on the similarity value, then the value is then grouped based on certain classes. One method of calculating distance in KNN [28], [29] is using Euclidean Distance. If the result value is greater then the level of similarity between the training data and test data will be further apart, on the contrary, if the result value is getting smaller then the level of similarity between the training Javanese data and test data will be closed according to Equation 3.

$$d_{ij} = \sqrt{\sum_{k=1}^{p} (x_{ik} - x_{jk})^2} \quad (3)$$

3.5 Framework

The LBP feature has been implemented in the process of recognizing Javanese characters on the testing image in the form of Javanese script sentence images. The dilation process is part of the image morphology that serves to thicken the image so that it can detect the outermost point that is close to other parts of the image, such as the letters 'ce', 'ri', 'ta' which are illustrated in Figure 2.

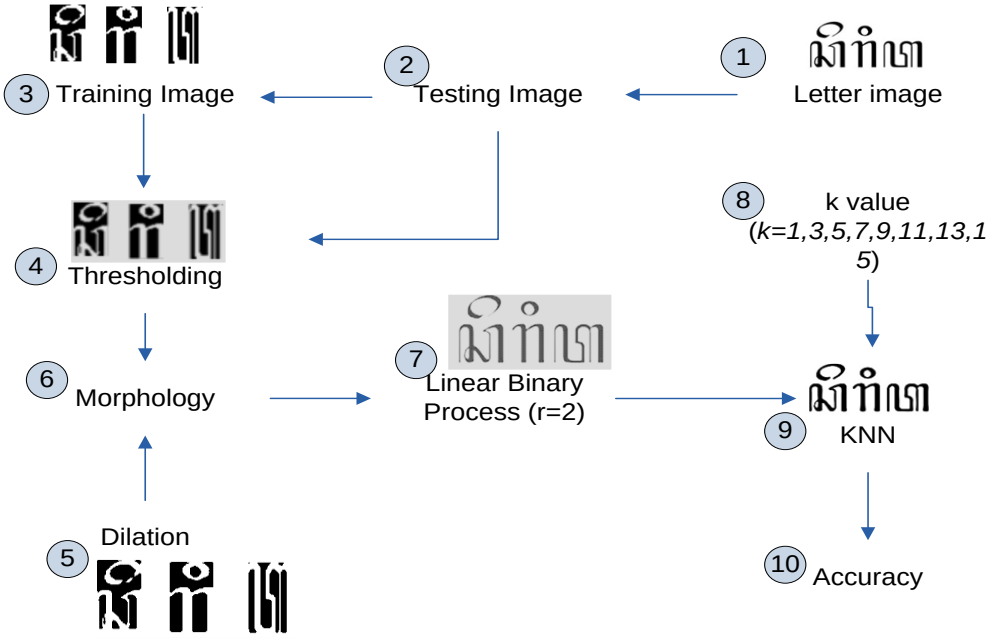


Figure 2. Proposed Method

4. Results and Discussion

4.1 Data Collection Procedures and Analysis Techniques

At this stage of research, data collection procedures were carried out for research. The data was used in the form of images of Javanese script in the form of photos as in Figure 3. The data that will be used in the study consists of 100 training data in the form of images of basic Javanese script letters or manners totaling 20 data and images of Javanese script vowels ('i','u', 'e', 'o') totaling 80 data. The training data used are 100 images, consisting of 20 basic letters or ways with the suffix 'a' sound, 20 vowels with the 'i' suffix, 20 vowels with the 'u' suffix, and 20 vowels with the 'e' suffix. ', and 20 vowels ending in 'o'. The training data with a pixel size of 24 x 42 is of the type bitmap picture or BMP. The

test data is 10 Javanese script image data with different sentences. Data analysis is used to process data obtained in research into information so that the data can be easily understood and useful in research.

No	Citra	Huruf	No	Citra	Huruf	No	Citra	Huruf
1		ha	2		hi	3		hu
4		he	5		ho	6		na
7		ni	8		nu	9		ne
10		no	11		ca	12		ci
13		cu	14		ce	15		co
16		ra	17		ri	18		ru
19		re	20		ro	21		ka
22		ki	23		ku	24		ke
25		ko	26		da	27		di
28		du	29		de	30		do
31		ta	32		ti	33		tu
34		te	35		to	36		sa
37		si	38		su	39		se
40		so	41		wa	42		wi
43		wu	44		we	45		wo
46		la	47		li	48		lu
49		le	50		lo	51		pa

No	Citra	Huruf	No	Citra	Huruf	No	Citra	Huruf
52		pi	53		pu	54		pe
55		po	56		dha	57		dhi
58		dhu	59		dhe	60		dho
61		ja	62		ji	63		ju
64		je	65		jo	66		ya
67		yi	68		yu	69		ye
70		yo	71		nya	72		nyi
73		nyu	74		nye	75		nyo
76		ma	77		mi	78		mu
79		me	80		mo			ga
28		gi	83		gu			ge
29		go	86		ba			bi
30		bu	89		be			bo
31		tha	92		thi			thu
32		the	95		tho			nga
33		ngi	98		ngu	99		nge
100		ngo						

Figure 3. Dataset

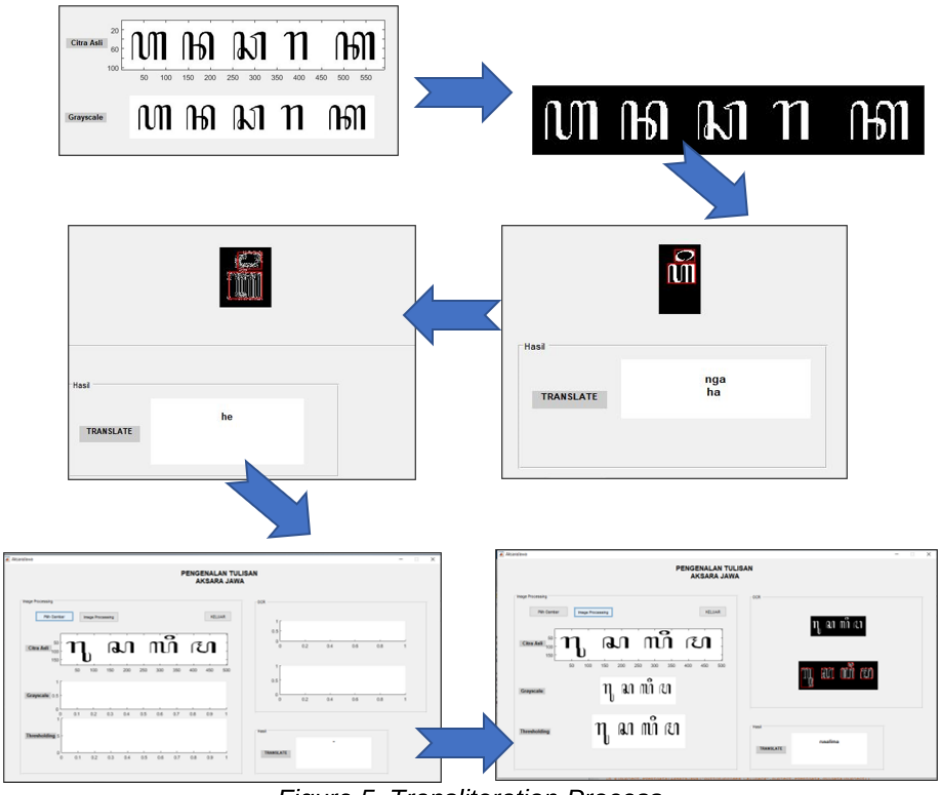


Figure 5. Transliteration Process

The next step is cropping the letters and saving them in jpg type format. The cropped image is subjected to a thresholding process and stored with type BMP. The thresholded training image is then cut back to fit the letters and is resized to a size of 24x42 pixels then save as type with Monochrome Bitmap type. The choice of a monochrome bitmap is because the pixel BMP is only one bit, allowing each pixel to display one color or appear as black and white. The image of the Javanese script in Table 1 is the image data that will be tested. The Javanese script image will be processed by segmentation image processing with thresholding and morphology methods and perform character

recognition for Javanese script letters which are then cropped on each character. After cropping, the KNN algorithm will perform the character recognition process by performing calculations to determine the accuracy value as shown in Figure 5.

Table 1. Image Recognition using KNN LBP

No	Image	Original Letter	Recognition Letter	Accuracy
1		Bahasa jawa	hanacaraka	100%
2		Baju baru	bajubaru	100%
3		Batako	batako	100%
4		Cerita	cerita	100%
5		Gula batu	gulabatu	100%
6		Kacamata	kacamata	100%
7		Matematika	matematiha	80%
8		Nasi basi	tusibasi	75%
9		Rusalima	rusalima	100%
10		Salatiga	sahabiga	50%
		Average accuracy		90,5%

Table 2. Image Recognition using KNN

No	Image	Original Letter	Recognition Letter	Accuracy
1		Bahasa jawa	hanacaraka	100%
2		Baju baru	bajubaru	100%
3		Batako	bataka	33,3%
4		Cerita	cerita	100%
5		Gula batu	galabatu	75%
6		Kacamata	kacamata	100%
7		Matematika	matematiha	80%
8		Nasi basi	sasabasa	25%
9		Rusalima	rasalama	50%
10		Salatiga	sahabiga	50%
		Average accuracy		61,33%

Local Binary Pattern (LBP) is a simple but very efficient extraction technique that labels pixels from an image with a pixel area threshold by considering them as binary (Pietikäinen, 2010). Due to LBP's ability to distinguish between image objects and simple computations, LBP feature extraction is used in this study to assist in the Javanese script

transliteration process. The use of LBP feature extraction is very helpful, especially for images that have separate objects in the study such as the letters 'i', 'e', and 'o'. Based on Table 1, the average accuracy value is 90.5%. The accuracy value of 100% is the highest and 50% is the lowest. In Table 2, using only KNN without extraction features, the accuracy drops significantly with an average accuracy gain of 61.33%, the highest accuracy is 100% and the lowest accuracy is 25%.

5. Conclusion

Based on the results, this experiment has been carried out starting from the preprocessing stage, feature extraction, and classification. It can be concluded that the classification using the K-Nearest Neighbor (KNN) and LBP algorithms obtained an average accuracy of 90.5% with the highest accuracy being 100% and the lowest accuracy being 50%. Extraction of the LBP feature is proven to increase the accuracy by up to 29.17% while the highest accuracy is still 100% and the lowest accuracy obtained without using LBP is only 25%. In the next research, it is better to do a cropping process, removing noise. To improve accuracy, experiments can be carried out on large datasets with a long sentence that includes the vowel aiueo and using deep learning classification algorithms such as Convolutional Neural Networks.

Notation

The example of notation can be described with the following description:

d_{ij} : Distance between object i and j
x_{ij} : The value of the object i in the k-th variable
x_{jk} : The value of the object j in the k-th variable
p : The number of observed variables

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