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Braille Detection Application Using Gabor Wavelet and Support Vector Machine

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Abstract
Difference any exchanging of several kinds' information such visual, printed or written form between impairments vision or blind with normal will cause problem especially in written form. For instance, in the assistance of a blind child by family with normal vision. One of family role is education to help their children to study and understand about their learning development from home, particularly for blind children. In this study, braille letters can be identified through images obtained using a scanner to help parents and families of a blind child in learning assistance by implementing the Gabor Wavelet feature extraction method. The features used are standard deviation, mean, variance, and median with theta angles of 00,300,450,600,1200,1350,1800 and wavelengths 3,6,13,28, and 58. These features will be combined and used as input as test data and training data. at the Support Vector Machine (SVM) classification stage and generates words in the alphabet. The braille letters detected in this study were small braille letters, capital braille letters, punctuation marks, and numbers. The test is carried out using a multi-class confusion matrix scenario to determine the level of accuracy, precision, and recall. Based on the results of tests carried out using 758 braille data, the accuracy value is 98.15%, the precision value is 97.66% and the recall value is 98.28%. From these results it can be concluded that the Gabor Wavelet feature extraction method and the Support Vector Machine (SVM) can be used to identify braille letters.

Keywords: Gabor wavelet, Braille, SVM

INTRODUCTION

The exchange of information in the digital era, especially in visual and printed forms, is common for people with normal vision, but it is different from someone who has visual impairments or is blind. These differences will cause problems in exchanging information in written form. For example, in the assistance of a blind person by a family with normal vision.

The family is an important role in the initial process of children's education in developing the potential of children. Parents have important roles and responsibilities in educating children in the family environment [1]. In the aspect of education, learning is not only done at school, but also at home. In this case, parents play an important role in helping children understand their learning development. A blind person in writing and reading uses the braille system, of course not everyone with normal vision has the ability to read the braille letter. This causes parents to have difficulty in accompanying a blind child in learning.

So far, braille has been translated by matching the braille letters one by one with the letters of the alphabet until they are legible. For people who are still not fluent in reading braille, this method is less effective because it will take a long time to understand what the writing means. Therefore, it is necessary to develop an intelligent system that helps normal people to recognize braille easily.

Braille is tactile writing consisting of a series of raised dots that represent letters, numbers, and symbols. Braille letters are composed of six dots, two horizontally and three vertically [2]. For the visually impaired in reading braille, they use the sense of touch, namely by using the tips of the fingers. Braille is an important medium in gaining knowledge for the blind so that this ability is a basic skill that must be possessed [3].

In the process of writing, it uses a different writing instrument, namely a reglet in the form of a perforated printing board that is clamped on writing paper and then using a blunt nail as a braille printer. In order for the raised dots to last a long time, the thickness of the paper is something that must be considered.

Research related to braille recognition has been carried out using the hebbrule artificial neural network method which processes braille images into binary images and then continues with the training process and letter recognition has a success rate of 73.043%. [4].

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Another study using the vertical and horizontal projection method has produced an accuracy rate of 84.6%. [5] The template matching method has also been used in the identification of braille letters and gave recognition results of 92.3%. [6] Other algorithms such as blob analysis and artificial neural networks can recognize braille characters and translate them into alphabetic letters with an accuracy rate of 99% [7]. The application of the k-nearst neighbor algorithm and the gray level coocurrence matrix in converting braille to android-based text obtains accuracy results that are influenced by many factors, one of which is the image acquisition process that causes characters to be undetected. [8]. Another study used backpropogation and gray level coocurrence matrix as feature extraction methods which resulted in an average success rate of 90%. [9] The naive Bayes method has been used to recognize the pattern of braille characters and then converted it into audio form and produces an accuracy rate of 88.172% in recognizing braille characters. [10]

Based on the research that has been done, in braille pattern recognition using a feature extraction algorithm has a fairly good level of accuracy with results above 90%. There are three methods of feature extraction, namely Discrete Wavelet Transformation (DWT), Gray Level Co-occurance Matrix (GLCM), and Gabor Wavelet (GW). In a study that compared the three methods, the Gabor Wavelet method produced the highest accuracy value. [11]. However, the feature extraction algorithm only functions to obtain the characteristics of a character, so to be able to fully recognize the character requires a classification process based on these characteristics, one of which is Support Vector Machines. This method is proven to have a high level of accuracy in the classification process. As in a study conducted by [12] the SVM method used in character recognition on vehicle number plates resulted in an accuracy rate of 91% in classification.

Therefore, in this study, we will apply a method that combines the Gabor Wavelet method as a feature extractor from braille characters with the Support Vector Machine method to classify previously obtained characteristics. This study will use a document containing braille text as a data source for training data and test data. This research is expected to produce an intelligent system that can identify Braille letters into letters of the alphabet.

LITERATURE REVIEW

Previous research has included:

1. Research by (Sahaduta & Lubis, 2013) with the title Gray Level Coocurence Matrix as Feature Extractor in Braille Script Recognition aims to identify braille script using backpropogation and Gray Level Coocurence Matrix (GLCM) methods. In this study, it can be concluded that to recognize the points in Braille characters, a backpropagation neural network is used. The success rate of the introduction of braille script in this study is quite good, which is above 90% and some are 100%.

2. Research by (Bahri & Maliki, 2012) with the title Comparison of Template Matching and Feature Extraction Algorithms in Optical Character Recognition aims to compare the Template Matching and Feature Extraction Algorithms in translating characters in digital images into text format. Based on the test results, the feature extraction algorithm has a better accuracy rate than the template matching algorithm and the feature extraction algorithm is better used in OCR than the template matching algorithm. And also the template matching algorithm takes a long time to recognize documents.Penelitian yang dilakukan oleh (Sari, Rasyad, & Evelina, 2017) dengan judul Identifikasi Huruf Braille Berbasis Image Processing Real Time bertujuan untuk membuat *prototype* yang dapat mengenali huruf braille melalui kamera *Logitech C600* dengan benar secara *real time*. Penelitian ini menggunakan metode *template matching* dan menghasilkan tingkat akurasi sebesar 92,3% dan eror sebesar 7,7%.

3. Research conducted by (Ronando & Sudaryanto, 2018) with the title Audio-Based Braille Pattern Recognition System Using the Naïve Bayes Method aims to recognize braille using the nave Bayes method. In this study, after recognizing braille letters, they will be converted into audio form using a raspberry pi device and produce an accuracy rate of 88.172% and the average response time of the device into audio form is 5 seconds.

This research is based on previous research which has relatively the same characteristics in terms of research themes. However, this study has differences in terms of research methods, tools used, and research outputs. In previous studies with the same research object, namely braille, the use of methods and process steps was different. As in the research conducted by (Sahaduta & Lubis, 2013) who recognized braille script using the Gray Level Coocurence Matrix (GLCM) feature extraction method and backpropogation classification, while in this research.

This method uses Gabor wavelet feature extraction and support vector machine classification. The use of the Gabor wavelet feature extraction method was chosen based on research by (Bahri & Maliki, 2012) which compared the feature extraction method used in Optical Character Recognition (OCR) and concluded that the Gabor wavelet method was the most appropriate to be applied in OCR.

In a previous study by (Sari, Rasyad, & Evelina, 2017) using a Logitech 600 camera as a tool to take an input image which then produces output in the form of alphabetic identification and binary data from Arduino UNO in the form of an LED indicator, this study immediately displays the output results. in the form of letters of the alphabet on the computer screen where the application is run. In a previous study by (Ronando & Sudaryanto, 2018) produced audio output in the introduction of braille, while in my research the results of braille recognition were in the form of a word in the alphabet.

RESEARCH METHODOLOGY

This research was conducted in several stages. These stages can be seen in Figure 1 below.

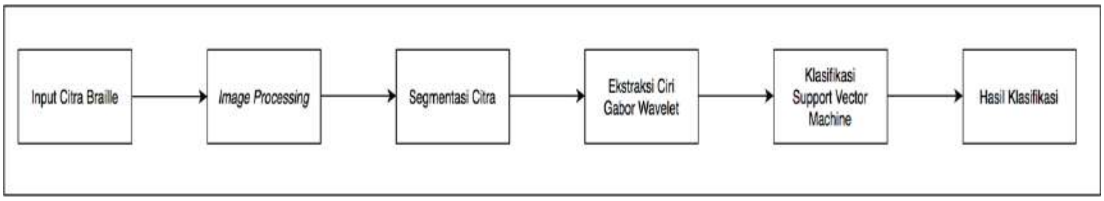

Fig. 1. Research stages

The first stage is the input process for braille images taken using a scanner. The image is then saved using the .jpg, .bmp, and .png formats. The image used in this study is a braille image in the form of words. Then the image processing stage is carried out on the image to prepare the image for further segmentation and extracting its characteristics using Gabor Wavelet. From the results of feature extraction, it will be stored as training data and test data to be classified using the Support Vector Machine method.

Image Preprocessing

In *image preprocessing stages*, the image will be carried out by several processes, including the following:

1. Grayscale is a process to convert the input image into a gray image. The value of each image pixel entered initially has an RGB value and then the average value is calculated so that the color pixel value changes and becomes a gray value.

2. Median Filter is a process that serves to remove noise in the previous grayscale image. The median value is obtained by calculating the middle value of each mask.
3. Binary is a process to convert a gray image into a black and white image. The pixel value is changed based on the threshold value, namely by calculating the average value of the gray level. If the pixel value is greater than the threshold value, it will be changed to 255 or white and vice versa, if it is smaller than the threshold value, it will be changed to 0 or black.
4. Dilation is a process used to thicken white pixels, so that the originally black braille dots will thin out. It aims to eliminate very small dots or noise.
5. Erosion is a process used to thicken black pixels, so that it will return the size of the braille dots to their original size.
6. Contour normalization is needed because the image contours that are read on the system have different sizes and shapes, so that in this process changes will be made to the shape and size of all braille points.

Image segmentation

At this stage, the images will be grouped by letter and then will be segmented, so that it will produce an image of each letter for the feature extraction process.

Gabor Wavelet feature extraction

The feature extraction stage is carried out using the Gabor Wavelet method. This stage will discuss the process of calculating the characteristic value of an image according to the parameters used. The stages of the Gabor Wavelet feature extraction process can be seen in figure 2.

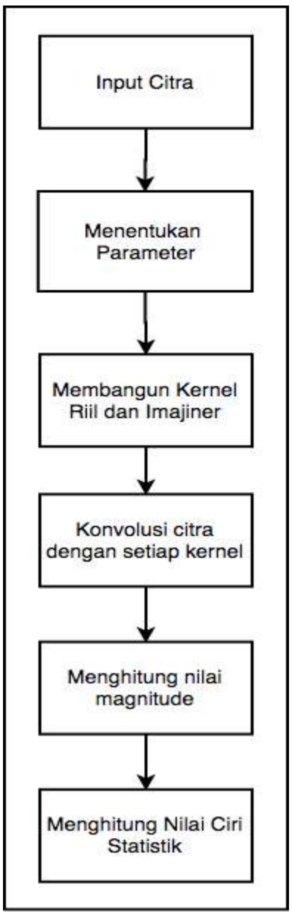

Fig. 2. *Gabor Wavelet* Process

Gabor wavelet feature extraction method has six main processes:

1. The image input process is done by entering the image of the letters that have been previously segmented. Then the image will be resized to equalize the size of all the images to be extracted.
2. In kernel development, several parameters are needed, including which represents the wavelength, θ is the orientation angle from normal to parallel from the Gabor function, ψ is the phase offset, is the sigma parameter or standard deviation of the Gaussian envelope and is the aspect ratio spatially and to determine the ellipticity of the support of the Gabor function.
3. Build real and imaginary kernels from Gabor wavelet using the following formula [13]: 4.

$$g(x,y) = \frac{1}{2\pi\sigma_x\sigma_y} exp\left(-\frac{1}{2}\left[\frac{x'^2}{\sigma_x^2} + \frac{y'^2}{\sigma_y^2}\right]\right) cos(2\pi F x') \quad (1)$$

$$g(x,y) = \frac{1}{2\pi\sigma_x\sigma_y} exp\left(-\frac{1}{2}\left[\frac{x'^2}{\sigma_x^2} + \frac{y'^2}{\sigma_y^2}\right]\right) sin(2\pi F y') \quad (2)$$

$$x' = x\cos\theta + y\sin\theta \quad (3)$$

$$y' = -x\sin\theta + y\cos\theta \quad (4)$$

$$output = \sqrt{r^2 + im^2} \quad (5)$$

Where F is the frequency, then q is the angle of orientation to the image ranging from 0 to 2p, s is sigma. In the above equations, it is divided into two, namely the real kernel and the imaginary kernel. Equation 1 is a real kernel and equation 2 is an imaginary kernel. Meanwhile, equation 5 is the formula used to calculate the results of the convolution between the image with the real kernel and the image with the imaginary kernel.

4. The next stage is the image convolution process with each kernel that has been built and then will produce a real convolution image and an imaginary convolution image.
5. Then, calculate the magnitude value of all the previous convolution images. This calculation is done using the equation 5.
6. From the magnitude value generated, the next step is to calculate the statistical characteristics of the image that will be used for the classification process. In this study using the statistical value of the mean, standard deviation, variance and median.

Support Vector Machine Classification

Support Vector Machine is a learning method used for binary classification, basically looking for the best hyperplane whose function is to separate the two classes in the input field. In the SVM method, the search and separation of hyperplanes that are in 2 classes will be carried out. Hyperplane as the best separator can be found by looking for the hyperplane margin and looking for the maximum point value. Margin is the distance between the hyperplane and the closest pattern of each class. The closest pattern is called the Support Vector. Initially, SVM was developed to solve the problem of two classes and then redeveloped to classify more than two classes or multiclasses. The multiclass classification is divided into two, namely one against all or one against all (OAA) and one against one or one against one (OAO) [14]. In this study using the One Against All method with the following equation to determine the class of new data (x) based on the largest hyperplane value using the following equation. [15]

$$Class\ x = argmax(\textstyle\sum_{i=1}^{m} \alpha_i y_i K(x, x_i) + b \quad (6)$$

This SVM classification stage will produce words in letters of the alphabet according to the image that has been entered in the system.

FINDING AND DISCUSSION

Interface

The results of the design and implementation in this study are in the form of the application display when used, which is like figure 3. This page is the starting page as well as the result page of the input image identification.

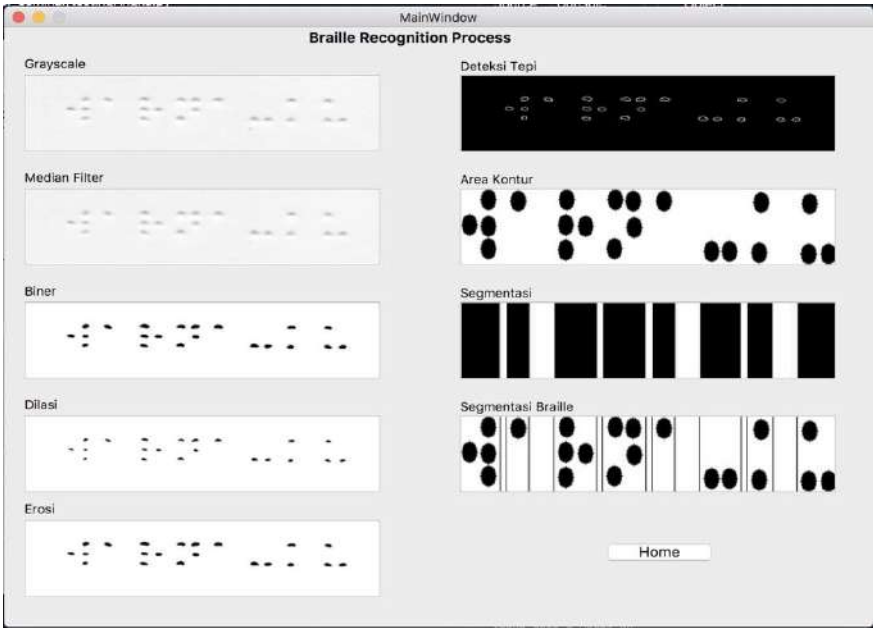

Fig 3. Identification result

In Figure 3 there is a table which is the result of feature extraction from the segmentation results of each letter in the input image. Then for the identification results in the form of words in the alphabet. Then for the voice button, is the pronunciation of the identification results.

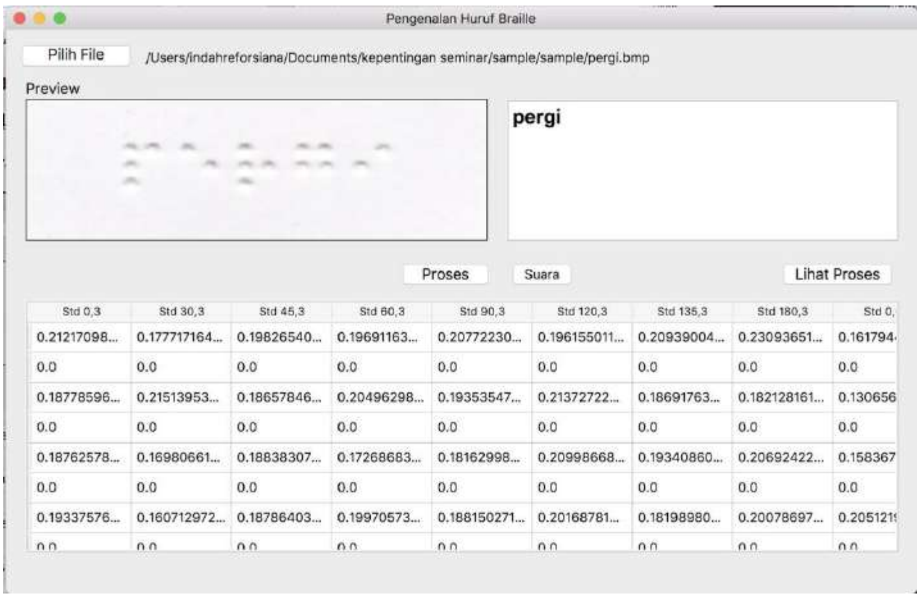

Fig. 4. Image processing process

At the fig. 4 is a page that contains the results of the image processing stage, from grayscale to braille segmentation.

RESULTS

Application testing is carried out after the coding stage has been completed. The testing phase aims to determine the level of success of the classification process that has been built. The implementation of system testing in this study was carried out by creating a multi-class confusion matrix and also to validate the data that had been tested on the application, 15 words would be taken randomly to be read directly by a blind person.

Through the confusion matrix, the results of testing accuracy, precision and recall can be known. In the multi-class confusion matrix measurement, there are four terms to represent the results of the classification process, namely TP (True Positive) the number of positive data correctly classified by the system, TN (True Negative) the number of negative data correctly classified by the system, FN (False Negative) the number of negative data that is classified incorrectly by the system, FP (False Positive) the number of positive data that is classified incorrectly by the system. Then calculating accuracy is obtained from the number of diagonal values from the confusion matrix divided by the total value of the predictions, calculating precision is obtained from the number of correct values from the class divided by the number of predictions from the class, and recall is obtained from the number of correct class values from the class divided by the number actual of class. The test data used were 758 letters in the form of words and braille punctuation and training data as many as 6 images for each class. The equation for measuring the three parameters is presented in the following equation.

$$\text{Accuracy} = \frac{TP+TN}{TP+FP+FN+TN} \tag{7}$$

$$\text{Precision} = \frac{\sum_{i=1}^{n}\left(\frac{TP_i}{FP_i+TP_i}\right)}{n} \tag{8}$$

$$Recall = \frac{\sum_{i=1}^{n}\left(\frac{TP_i}{FN_i+TP_i}\right)}{n} \tag{9}$$

The result will be provided in the *confusion matrix* table.

Tabel 1. Con*fusion Matrix Multi-Class*

		Prediksi																																				FN	Recall
		spasi	!	Tanda Angka	Tanda Kapital	,	-	.	/	:	?	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z		
Aktual	spasi	86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	!	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Tanda Angka	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Tanda Kapital	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	,	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	-	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	.	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	/	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	:	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	?	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	a	0	0	0	0	0	0	0	0	0	0	87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	b	0	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	c	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	d	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	e	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	g	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	h	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0,833
	i	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	j	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	k	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0,967
	l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	n	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39	1	0	0	0	0	0	0	0	0	0	0	0	1	0,975
	o	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	1
	p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	1	0	0	0	0	0	0	0	0	0	1	0,957
	q	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	1
	r	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	34	0	0	0	0	0	0	0	0	2	0,944
	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	1	0	0	0	0	0	0	1	0,941
	t	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	18	0	0	0	0	0	0	1	0,947
	u	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	18	0	0	0	0	0	4	0,818
	v	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	1
	w	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	1
	x	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	1
	y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	1
	z	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	1
FP		1	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	3	0	1	0	2	0	0	1	0	0	0	0	0	0		
TN		671	748	752	747	748	748	744	750	749	747	671	733	745	743	720	749	735	739	712	744	728	738	728	718	741	735	749	722	741	738	736	750	749	750	747	751		
Presisi		0,989	1	1	1	1	1	0,714	1	1	1	1	1	1	1	1	1	1	0,938	1	1	1	0,95	0,9	1	0,941	1	0,778	1	1	0,947	1	1	1	1	1	1		

(yellow) = *True Positive (TP)* FP = *False Positive (FP)*
TN = *True Negative (TN)* FN = *False Negative (FN)*

Based on the table, the accuracy value is obtained by calculating the accuracy as in equation 7 based on the test results obtained from the confusion matrix that has been done previously as follows:

$$\text{Accuracy} = \frac{744}{758} X 100\%$$
$$= 98{,}15\%$$

Then the precision value used is the average precision for each class of the classification model. The precision value for each class and the average is calculated using equation 8.

$$\text{Precision} = \frac{35{,}157}{36} X 100\%$$
$$= 97{,}66\%$$

And for the recall value used is the average recall value of the total recall in all classes. The following equation is used to calculate the average recall value

$$Recall = \frac{35{,}3827}{36} X 100\%$$
$$= 98{,}28\%$$

So that in testing using the confusion matrix, the average value of accuracy obtained is 98.15%, precision is 97.66% and recall is98.28.%.

DISCUSSION

From the implementation and testing that has been done previously, it was found that this application can identify braille letters in the form of numbers, uppercase letters. lowercase, and also punctuation with good results. This can be proven in the confusion matrix test which produces an average value of 98.15% accuracy, 97.66% precision and 98.28% recall.

Based on the test values obtained from the confusion matrix table, it can be interpreted if the tests that have been carried out have a successful classification quality because they obtain high precision and recall values. [16] The high accuracy of the classification process method depends on the amount of braille character test image data used, the more images used, the greater the accuracy value, and vice versa if the less the amount of test image data, the smaller the accuracy value. Then, the slope in writing braille and also the presence of dots or stains on the paper used to write braille can affect the identification results. For example, there are stains in the form of lines that are close to the braille point to be processed. In the reading results, letters can still be produced according to letters whose characteristic values are close to the previous training data.

The time required by the braille identification application to identify an image of a word in braille into alphabet letters and sounds will take quite a short time, namely 4 seconds on average, but for a braille image in the form of numbers it is relatively longer, namely the average 11 seconds to produce sound output. Then for the resulting sound output, it will be read with Indonesian pronunciation provided by Google, so if you want to get the sound output, an internet connection is needed. However, if there is no internet connection, this application can still run and can still produce identification results in the form of words in the letters of the alphabet.

CONCLUSION AND FURTHER RESEARCH

Based on the research that has been done, the development of a digital image processing application to identify braille letters into the alphabet has been successfully carried out by extracting braille characters using the Gabor Wavelet method to be further classified by the Support Vector Machine (SVM) method. Both methods can identify braille letters in the form of uppercase letters, lowercase letters, numbers and punctuation marks with the test results from the confusion matrix method at an accuracy rate of 98.15%, an average precision value reaching 97.66% and an average value recall reached 98.28%. The time required by the application to identify an image of braille letters is on average 4 seconds and for numbers in braille it is 11 seconds. The test was carried out using 758 randomly distributed test data. The inaccurate classification results in this study are influenced by certain factors such as the presence of stains on the paper around the input braille word image and the slope of the input braille image writing.

In this study, there are still some limitations that are expected to be developed further for further research. Some things that can be given for the development of this application are that this application can be developed to be able to identify images that contain sentences in braille and also combine letters and punctuation with numeric characters in an image and can distinguish between braille dots and stains on paper.

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REFERENCES

Adak, C. (2014). Gabor Filter and Rough Clustering Based Edge Detection. *International Conference on Human Computer Interactions (ICHCI).* Chennai, India: IEEE.

Adhitya, Gigih. (2016). Peningkatan Kemampuan Membaca Permulaan Huruf Braille Melalui Metode Scramble Pada Siswa Tunanetra Kelas 1 SLB A YPTN Mataram.

Anwar, S. (2016). *Klasifikasi Kerusakan Kawasan* Konservasi Dengan Metode Support Vector Machine (Svm) Menggunakan Kernel Gaussian: Studi Kasus The Nature Conservancy. *Jurnal TELEMATIKA MKOM Vol8,* 89-96.

Eninggar, Y., Syafei, W., & Setyono, B. (2011). Pengenalan Huruf Braille Berbasis Jaringan Syaraf Tiruan Metoda Hebbrule.

Fibriananda, M., & Bhawiyuga, A. (2018). Analisis Perbandingan Akurasi Deteksi Serangan Pada Jaringan Komputer Dengan Metode Naïve Bayes Dan Support Vector Machine (SVM). *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer*, 3112-2123

Harimi, A. (2018). Strategi Pembelajaran Kemahiran Menulis Bagi Peserta Didik Tunanetra. *Prosiding Konverensi Nasional Bahasa Arab IV*, (pp. 51-56).

Hsu, C. W., & Lin, C. J. (2002). A Comparison of Methods for Multiclass Support Vector Machines. *IEEE TRANSACTIONS ON NEURAL NETWORKS, Vol 13, No 2.*

Iswara, A., Sumpeno, S., & Purnomo, M. (2013). Aplikasi Pengenalan Kata Pada Huruf Braille dan Pelafalannya. *JURNAL TEKNIK POMITS*, 335-340.

Jailani, M. Syahran. (2014). Teori Pendidikan Keluarga dan Tanggung Jawab Orang Tua dalam Pendidikan Anak Usia Dini*. Jurnal Pendidikan Islam Vol8,* 245-260

Ronando, E., & Sudaryanto, A. (2018). Sistem Pengenalan Pola Huruf Braille Berbasis Audio Menggunakan Metode Naïve Bayes. *Jurnal Ilmu Komputer dan Desain Komunikasi Visual Vol3*, 43-52.

Sahaduta, Y., & Lubis, C. (2013). Gray Level Coocurence Matrix Sebagai Pengekstraksi Ciri pada Pengenalan Naskah Braille. *Seminar Nasional Teknologi Informasi dan Multimedia.* STMIK AMIKOM Yogyakarta.

Sari, D., Rasyad, S., & Evelina. (2017). Identifikasi Huruf Braille Berbasis Image Processing Real Time. *Seminar Nasional Sains dan Teknologi 2017*, 68-80.

Subur, J. (2015). Pengenalan Huruf Braille Menggunakan Metode Blob Analysis dan Artificial Neural Network.

Sugiarto, E. (2013). Pengenalan Karakter pada Plat Nomor Kendaraan Berbasis Support Vector Machine. *Techno.COM*, 1-15.

Sulviyani, I., Novamizanti, L., & Atmaja, R. (2017). Perancangan Konversi Braille ke teks Berbasis Android.

Supriyati, E., & Khotimah, T. (2014). Perbandingan Ekstraksi Ciri pada Data Mammogram untuk Identifikasi Mikrokalsifikasi. *Jurnal SIMETRIS*, 153-160.