HANDWRITING RECOGNITION USING LEARNING VECTOR QUANTIZATION AND DIRECTIONAL ELEMENT FEATURE METHODS

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ABSTRACT

Handwriting recognition is part of Optical Character Recognition (OCR) is a process to recognize the character of a digital image. Images of handwriting will be converted into digital form, which will be able to known system. The classification method used for the process of learning in handwriting recognition. Based on previous Research Methods Learning Vector Quantization (LVQ) are able to recognize the image with the level of accuracy of 61.07% and for data that are not yet trained amounted to 48.17%. Handwriting recognition process through a variety of processes including process grayscale, threshold savuola, segmentation and extraction of characteristics which then proceeds from the extraction will be entered on the LVQ method to do the training and testing. The process of LVQ Method combined with characteristic extraction method of Directional Element Feature, DEF method used to get the hallmark of an image that is by looking at the difference in contour and without skeletonisasi process. After testing the system with the Black Box method and calculated accuracy can be drawn the conclusion that the program is functioning correctly. On the handwriting recognition features 73.80% degree of accuracy and for handwriting image that has not been done the learning of 36.99%.

Keywords: Handwriting Recognition, Learning Vector Quantization, Directional Element Feature, Extracting the characteristics, Artificial Intelligence

1. INTRODUCTION

The introduction of the image on the letter or often called Optical Character Recognition (OCR) is the conversion of handwritten image files into a form which is modified. The handwriting was later scanned using scanner to produce an image [1]. OCR a regular technique applied on different handwriting, one of which discusses the writing of latin alphabet and latin.

Language is one of the means of human communication. Therefore to communicate each other needed a language that can be understood as a means of connecting, this was disebabakan by the difference of the tribes, customs, culture and others [2]. Then to bridge these differences made the same language and to understand a language then needed an understanding of letters [2]. Sometimes a script difficult to be recognized when it is rendered, because each language has different characteristics that script. So with the growing information technology and a lot of research is done to do the introduction of a hand written script on a specific language by using the terknologi computer with OCR Techniques to approach using measuring the accuracy of a system in order to menganali a script in longhand.

Previous research on Learning Vector Quantization image able to recognize with accuracy the average value sebasar 61.07 and average accuracy of the result image has not done the learning of 48.17% [16]. Such research has yet to wear in addition to the traits of the extraction process of preprocessing that is used to view a hallmark of a character.

Directional Element Feature (DEF) is the characteristic extraction method has been widely used and proven to give good results, previous research on DEF coupled with SVM in Javanese alphabet handwriting recognition accuracy of results obtained amounting to 93.6% [4]. DEF method on OCR which saw the difference in contour and without undergoing the process of skeletonizing [4].

Method of Learning Vector Quantization will be combined with method extraction characteristics of Directional Element Feature to see the accuracy of handwriting recognition.

Based on the exposure that has been discussed, this research is intended to apply the methods of Learning Vector Quantization and Directional Element Feature on handwriting recognition.

The discussion will be written into the thesis entitled "**IMPLEMENTATION of LEARNING VECTOR QUANTIZATION and DIRECTIONAL ELEMENT FEATURE METHODS for HANDWRITING RECOGNITION**".

2. CONTENT OF PAPER

2.1 Theoretical Basis

2.1.1 Image

The image is a two-dimensional image is generated from a two-dimensional analog image continuous discrete images into the sampling process [5]. the imagery is distinguished into two types, namely the image of analog and digital imagery. The image is the output of a data recording system that is optical, analog or digital. Image data recording is divided into 2 IE Analog Image and Digital Image.

2.1.2 Analog Image

The analog image is the image of a continuous nature, such as the images on television monitors, x-rays, photos printed on photo paper, paintings, landscapes, the results of the CT scan, images recorded on a cassette tape, and others [5].

2.1.3 Digital mage

A digital image is a two-dimensional image that can be displayed on a computer screen as a set of discrete/digital called the pixel value/picture elements. In mathematical reviews, image is a continuous function of the intensity of the cahata on the two dimensional field [5]. An image can be defined as a function f (x, y) size M rows and N columns, with x and y coordinates are spatial, and amplitude of f at the point at coordinates (x, y) were named the intensity or level of keabuan of the image at that point. If the value of x, y and value of amplitude f overall finite (finite) and the discrete value then it can be said that the image is a digital image [6].

2.1.4 Pattern Recognition

Pattern Recognition (PR) or pattern recognition, is one of the branches of the AI (artifical intelegence) [6], which examines the creation of a system to recognize a particular pattern. The pattern in this case refers to the understanding of a complex composition sensing a stimulus that can be recognized by humans as an observer as a group object. Pattern Recognition is the process of the introduction of the back against the pattern has ever known. Therefore, When the same picture ever seen sebelmunya, then the process will recognize as something that had previously been experienced.

2.1.5 *Preprocessing*

Grayscale image handling tint black and white, which produces the effect of gray color, the color of the image declared with intensity. In this case, the intensity range from 0 up to 255. A value of 0 is black and 255 values stated stated white [6]. Here is the conversion of colored (RGB) image into grayscale.

$$I = (0.2989 * R) + (0.5870 * G) + (0.1141 * B) \quad (1)$$

Sauvola threshold threshold method is capable of detecting image handwriting very well, by calculating the threshold value of the dynamic range of the grayscale image standard deviation value [7].

$$T(x,y) = m(m,y) * \left(1 + k * \left(\frac{s(x,y)}{R} - 1\right)\right) \quad (2)$$

$$m(x,y) = \frac{\sum_{i=min}^{i=max}\sum_{j=min}^{j=max} img(i,j)}{i*j} \quad (3)$$

$$s(x,y) = \frac{\sum_{i=min}^{i=max}\sum_{j=min}^{j=max}(img(i,j)-m(x,y))^2}{(i*j)-1} \quad (4)$$

Image segmentation is a technique to divide the image into multiple areas or regions where each region has the resemblance of the attribute [7]. According to Gonzales and Wintz that segmentation is the process of the Division of an image into a number of parts or objects. Segmentation is a very important part in the analysis of the image automatically, for in this procedure the desired object will be tapped for the next process.

2.1.5 Directional Element Feature

DEF method on OCR which saw the difference in contour and without undergoing the process of skeletonizing [4].

Here are the stages that exist in the extraction of DEF [4]:

1. Resize

Resizing is used to resize pixel according to the needs in the process of ektraksi characteristics. This is done so that all the characters from the image segmentation results have the same size and yield traits of good in process dot orientation.

2. Dot Orientation

Directional Element Feature is the search value featured based on label directions of a pixel. In this method each pixel a foreground (pixel characters) on a digital image will be given the label (featured direction) by way of tracing the neighbors of each pixel a foreground unidirectional rotation clockwise where direction is used consisting of 4 directions.

3. Vector Construction

This stage to calculate the value of each pixel neighborliness has previously been through a process of dot orientation, first image will be divided into N1 x N1 areas that overlap as much as N1/2 pixel against a neighboring area.

The next area, each area was divided again into 4 sub-areas, namely A, B, C and D, which are exclusive of each other. Once retrieved amount of pixels in each sub area, will be multiplied by the respective number of elements on each sub-ketetanggan area with weights (w) in the sub-areas and aggregated from each element in the sub-areas with the formula as follows [4]:

$$x_j = w_A x_j + w_B x_j + w_C x_j + w_D x_j \quad (5)$$
$$j = 1,\ldots,4$$

j is the pixel neighborliness

Furthermore the DEF diperolh characteristic vector by combining the number of elements in every area into a single column vector V.

$$V = [X_1^1, X_2^1, X_3^1, X_4^1, \ldots, X_1^N, X_2^N, X_3^N, X_4^N] \quad (6)$$

Where N is the number of characters from each area. A vector V is what later so the input to the process of learning and testing.

2.1.4 Learning Vector Quantization

Many methods can be used to image the handwriting recognition, among others the method of Artificial Neural Network Backpropagation, Hough Transform, and Support Vector Machine. From some of the methods mentioned methods of Learning Vector Quantization is still not widely used. Learning Vector Quantization (LVQ) is a network of neural network architecture type single-layer feed-forward (Single Layer Feedforward) consisting of units of input and output units. A competitive layer will automatically learn to classify the input vectors [2]. Classes are obtained as a result of layers of kompetitifini depends only on the distance between the input vector. If the two input vector approach is the same, then a layer of competitive will put both the input vector into the same class [2].

$$Cj = \sqrt{\sum_{i=1}^{n}(X_i - W_j)^2} \qquad (7)$$

C_j = Euclidean distance value

X_i = input vector value

W_j = weights vector value

In addition LVQ always renew does it weigh a maximum number of epoch. Epoch, namely a cycle training which involves all the patterns. Equation 2 is the formula weight of LVQ used to update the values of the weights:

$$\overrightarrow{W_m} = \overrightarrow{W_m} + \alpha . (\overrightarrow{X} - \overrightarrow{W_m}) \qquad (8)$$

W_m = weights

α = learning rate

$\overrightarrow{X}$ = input

2.2 Analysis and Implementation

2.2.1 Analysis

The process is done in the application is divided into several parts where each process has a role in do handwriting recognition and evaluation of the answers of the exam. The process is done in Figure 1.

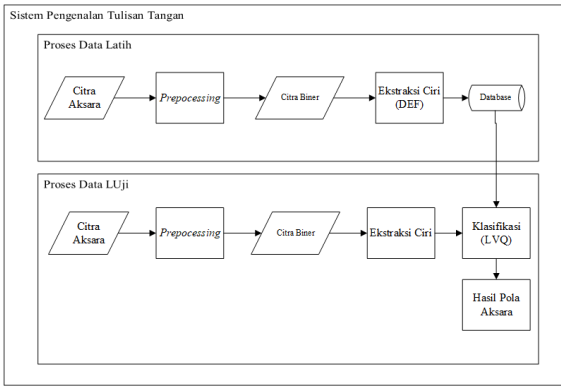


Figure 1. An Overview Of The System

2.2.2 Preprocessing

1. Grayscale: This step is changing the RGB image obtained from the results of the scan, then will be transformed into the image of keabuan, who had a 24-bit into 8-bit easier in the next process.
2. Savuola Threshold: At this stage the previous image has been through the process will be changed to grayscale images in black and white, the image will be counted as on savuola size 11x11 pixels, constant R: 128, and the K = 0.5, then will look for Mean, the Standard, and the Threshold . Following the results of the process of the threshold.

Table 1. Result Of Savuola Threshold

X/Y	0	1	…	532
0	255	255	…	255
1	255	255	…	255
2	255	255	…	255
3	255	255	…	255
…	…	…	…	…
956	255	255	…	255

3. Biner Process: at this stage of the process penghitungandari results threshold will be changed to 0 and 1, where 0 is white and 1 is black.
4. Segmentation: the image will be divided into Stages per character prior to the extraction process characteristics, segementasi performed on each line on the first image which is then followed by the truncation column, first image size will be calculated then browse to find the image pixel pixel black which will be the initial cutting of labels, then trace back to a single line of pixels if not found will be labeled end of the cutting. The same process is done on the cutting of the column.

2.2.3 Characteristics Extraction

On the process of extraction characteristics of directional element feature works by taking an image based on characteristics of the contour. Here are the stages on the DEF:

1. Resize: This stage of segmentation results image will be resized into a 15 x 15 pixels, image segmentation results so that all have the same size.
2. Dot Orientation: This step will navigate the pixels each pixel of a foreground neighborliness with the needle, as shown in the following figure:

X1	X2	X3
X8		X4
X7	X6	X5

Figure 2. Direction Table of DEF

When a black pixel is obtained then it will be done pengecakan with how to view neighboring pixels. Note table 3., when a black pixel is obtained then the checking is done sequentially from X 1-8. Checking stops when it finds the X which is the other black pixel. Then change the value of the pixel is black, who had 1 into value direction based on the rules below:

- If position X 1 or X 5 then its worth 5
- If the position of X 2 or X 6 then the value 2
- If position X 3 or X 7 then its value is 3
- If position X 4 or X 8, then its value is 4

3. Vector Construction: After the dot orientation will be calculated the value of each area that will be so characteristic of vector. The process does is divide the image into a 2 x 2 area with a size of 8 x 8 pixels each of which overlap. After that each area of yesteryear will be divided again into 4 sub-areas, namely A, B, C, D are mutually exclusive of each other, with large-area A = 2 x 2 pixel, B = 4, C = 6 x 6 pixels pixels, and D = 8 x 8 pixels. Then the vectors will be produced from this process as much as 16 vector that would later characterize the process of classification of LVQ. After making the counting of each pixel on each of the sub-areas with Parallels 5, then the obtained values from each of the sub-areas, such as following the calculation on A character:
   - x_1 = (0.0) + (5.2) + (22.7) + (37.11) = 0 + 10 + 154 + 407
   - x_2 = (0.0) + (5.1) + (22.5) + (40.9) = 0 + 5 + 110 + 360
   - x_3 = (9.3) + (19.5) + (26.7) + (31.8) = 27 + 95 + 182 + 248
   - x_4 = (4.2) + (11.5) + (16.7) + (18.8) = 8 + 55 + 112 + 144

   After making the counting of each pixel on each of the sub-areas with Parallels 5, then the obtained values from each of the sub-areas, such as following the calculation on A character:

   - V = [0, 10, 154, 407, 0, 5, 110, 360, 27, 95, 182, 248, 8, 55, 112, 144]

2.2.4 *Learning Vector Quantizaton*

The learning process where the system learn a number of existing data and generate the weights. The training data used is vector characteristics derived from the process before. The following table 2 data for weights and input.

Table 2. Initialize Weights and Data Input

Huruf	Kelas	Vektor Ciri	Ket
A	1	[0, 10, 154, 407, 0, 5, 110, 360, 27, 95, 182, 248, 8, 55, 112, 144]	Bobot (W_1)
B	2	[0, 0, 182, 1782, 0, 44, 168, 840, 0, 3, 297, 1554, 36, 95, 248, 1260]	Bobot (W_2)
C	3	[0, 3, 108, 507, 0, 0, 20, 162, 0, 64, 144, 256, 18, 120, 304, 650]	Bobot (W_3)
A	1	[0, 10, 96, 560, 0, 0, 95, 480, 20, 80, 126, 360, 0, 36, 133, 444]	Masukan (X_1)

Will then be determined in order for the process of learning, in this study determined the maximum paramaternya that is, looping as much as 1000, minimum error 0.01, 0.05, and learning rate reduction ratio of 0.1. After it is calculated with equation 7, to see the closest distance and here are the results of the calculation.

Tabel 3. Euclidean Distance Result

Vektor	Nilai
C_1	385,0233759
C_2	1944,918764
C_3	447,888379

From these results it can be seen that the distance (C) calculation of the obtained at the smallest C1, then it can be inferred that the target of the X 1 is the grade 1 and grade weights to-1 is also a class 1 means the target in accordance with the results of the calculation.

After the nearest distance calculation is done it will be done with weights change the equation 8 for target in accordance with the weight class.

Then here is an ultimate weight to be used in the process of introduction of the LVQ.

Tabel 4. Final Weights Result

Huruf	Kelas	Vektor Ciri	Ket
A	1	[0. 10. 151,1. 414,65. 0. 4,75. 109,25. 366. 26,65. 94,25. 179,2. 253,6. 7,6. 54,05. 113,05. 159]	Bobot (W_1)
B	2	[0. 0,5. 177,7. 1720,9. 0. 41,8. 164,35. 822. 1. 6,85. 288,45. 1494,3. 34,2. 92,05. 242,25. 1219,2]	Bobot (W_2)
C	3	[0. 3,35. 107,4. 509,65. 0. 0. 23,75. 177,9. 1.	Bobot (W_3)

		64,8. 143,1. 261,2. 17,1. 115,8. 295,45. 639,7]	

Introduction process will use the final weights obtained in the process of introduction of the LVQ.

Tabel 5. Euclidean Distance Result Recognition

Vektor	Nilai
C_1	365,7722071
C_2	1847,672826
C_3	425.49396

Judging from the results of the calculations then the smallest distance from the process of introduction is the weight of 1 (C1) and is a grade 1 i.e. the image of the letter A.

2.2.5 Functional Requirement Analysis

A functional needs analysis discussed in the form of activity, class, usecase and squence diagrams can be seen in Figure 3, 4, 5 and Figure 6.

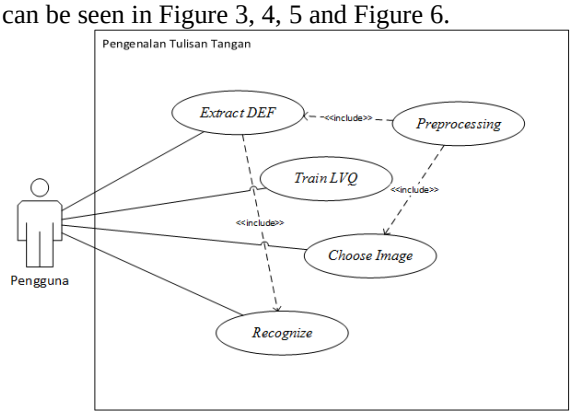


Figure 3. Usecase Diagram Handwriting Recognition System

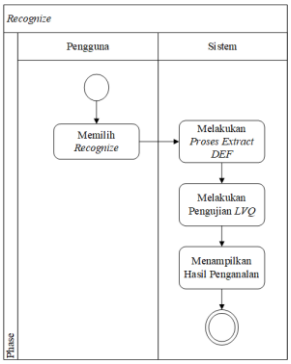


Figure 4. Activity Diagram Recognize Process

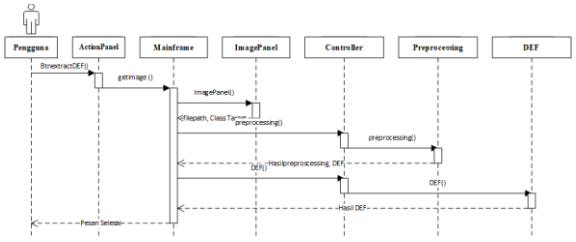


Figure 5. Class Diagram Extract DEF Process

2.2.6 System Architecture

As for the stage which is done in the design of this system deals with the goal of designing the interface and menus that are created on this patient buildup prevention system. The design of the system can be seen in Figure 7, 8.9, 10 and Figure 11.

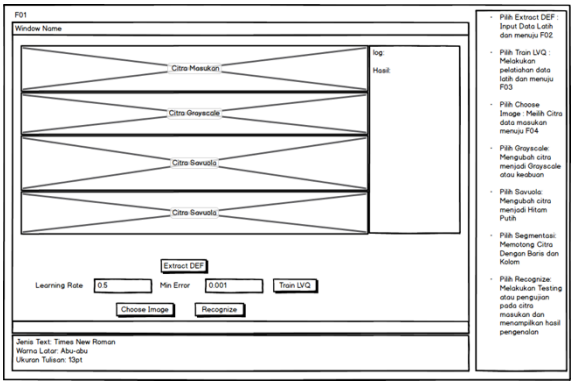


Figure 6. Architecture of User Interface

2.2.7 Implementation

The stage of system implementation is the next stage of the stages of the interface. At this stage the system would be tested and will show the results. So it can be result a solution. At this stage will be discussed, namely the implementation of the interface and the test results from the hardware device on the system.

2.2.8 Hardware Implementation

Hardware implementation describes the hardware that is used to implement the system.

Tabel 6. Hardware Implementation

Komponen	Spesifikasi
Processsor	2.4 GHz Intel Core i5
Memory	8 GB DDR3
VGA	Intel Iris 1536 MB
Harddisk	250 GB
Layar Monitor	Resolusi 1366x768 *pixel*

2.2.9 Software Implementation

Perangkat lunak yang digunakan untuk sistem pengenalan tulisan tangan adalalah sebagai berikut.

Tabel 7. Software Implementation

No	Perangkat Keras	Spesifikasi
1	Sistem Operasi	OS X Yosemite – 10.10.5
2	Bahasa Pemrograman	Java
No	Perangkat Keras	Spesifikasi
3	Perangkat Pendukung	Java Development Kit
4	Aplikasi Tools	Netbeans IDE 1.8.0_31
5	Permodelan	Microsoft Visio 2013

2.2.10 Interface Implementation

Here is an implementation of the interface of the system introduction to writing..

1. Main Menu Interface

In Figure 7 is the Display will appear the first time by the time the program is run in it there are a few buttons.



Figure 7. Interface Main Menu

2. Extract DEF Interface

Figure 8 display is on when the user performs the process of Extract DEF that is in the process of preprocessing and extraction of characteristics on imagery training.

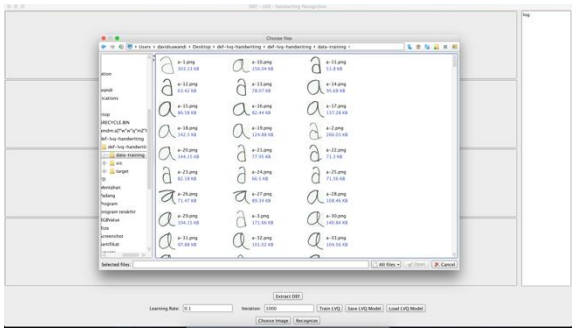


Figure 8. Extract DEF Interface

3. Recognize Interface

Recognize menu used to perform process pengennalan on the test image that will display the result of an introduction..

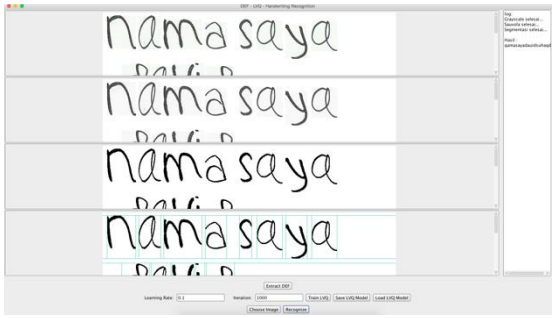


Figure 9. Recognize Interface

4. Error Message Interface

An error message will appear when the user is not doing the training process in advance when it will enter a test image.

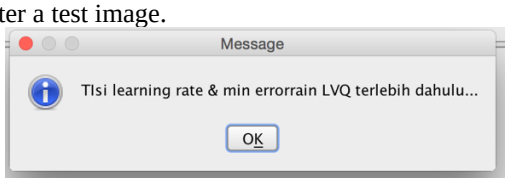


Figure 10. Error Message Interface

2.2.11 Accuracy of Testing Process

Testing accuracy will be calculated the value of accuracy or suitability of the handwriting recognition applications. Testing done after the data training conducted the training process. The accuracy of the testing will be done to the image that has been previously trained and image that has not been trained. The following is the formula for calculating the accuracy.

$$Akurasi = \frac{jumlah\ karakter\ sama}{jumlah\ seluruh\ karakter}\ X\ 100\% \qquad (2.10)$$

Table 8. Testing Result 1

No	Nama Citra	Akurasi Pengenalan
1	Uji-1.png	78.57%
2	Uji-2.png	82.85%
3	Uji-3.png	85.00%
4	Uji-4.png	65.90%
5	Uji-5.png	50.00%
6	Uji-6.png	65.21%
7	Uji-7.png	64.28%
8	Uji-8.png	60.52%
9	Uji-9.png	65.21%
10	Uji-10.png	73.33%
Hasil Akurasi		69.08%

Table 9. Testing Result 2

No	Nama Citra	Akurasi Pengenalan
1	Uji-1.png	78.57%
2	Uji-2.png	74.28%
3	Uji-3.png	100%
4	Uji-4.png	70.45%
5	Uji-5.png	46.66%
6	Uji-6.png	73.91%
7	Uji-7.png	75.00%
8	Uji-8.png	68.42%
9	Uji-9.png	43.47%
10	Uji-10.png	80.00%
Hasil Akurasi		63.25%

Table 10. Testing Result 3

No	Nama Citra	Akurasi Pengenalan
1	Uji-1.png	82.14%
2	Uji-2.png	74.28%
3	Uji-3.png	80.00%
4	Uji-4.png	84.09%
5	Uji-5.png	53.33%
6	Uji-6.png	69.56%
7	Uji-7.png	82.14%

No	Nama Citra	Akurasi Pengenalan
8	Uji-8.png	73.68%
9	Uji-9.png	52.17%
10	Uji-10.png	86.66%
Hasil Akurasi		73.80%

On testing above the best accuracy results obtained during the 3rd test with accuracy of 73.80% with learning rate parameter and a maximum of 0.010 looping 2000. For results that have the lowest degree of accuracy in the 2nd test with accuracy 63.25 learning rate parameter% at 0.05 and maximum looping 2000. The results obtained from test data that had previously been trained.

Following are the results of testing the accuracy of data that previously had never been tested.

Table 11. Testing Result 1

No	Nama Citra	Akurasi Pengenalan
1	Uji-1.png	32.14%
2	Uji-2.png	20.00%
3	Uji-3.png	40.00%
4	Uji-4.png	20.45%
5	Uji-5.png	30.00%
6	Uji-6.png	26.08%
7	Uji-7.png	21.42%
8	Uji-8.png	34.21%
9	Uji-9.png	34.78%
10	Uji-10.png	50.00%
Hasil Akurasi		30.90%

Table 12. Testing Result 2

No	Nama Citra	Akurasi Pengenalan
1	Uji-1.png	39.28%
2	Uji-2.png	28.57%
3	Uji-3.png	45.00%
4	Uji-4.png	31.81%
5	Uji-5.png	30.00%
6	Uji-6.png	30.43%
7	Uji-7.png	35.71%
8	Uji-8.png	50.00%
9	Uji-9.png	39.13%
10	Uji-10.png	40.00%
Hasil Akurasi		36.99%

Table 13. Testing Result 3

No	Nama Citra	Akurasi Pengenalan
1	Uji-1.png	42.85%
2	Uji-2.png	34.28%
3	Uji-3.png	15.00%
4	Uji-4.png	31.81%
5	Uji-5.png	26.66%
6	Uji-6.png	26.08%
7	Uji-7.png	28.57%
8	Uji-8.png	23.68%
9	Uji-9.png	30.43%
10	Uji-10.png	46.66%
Hasil Akurasi		30.60%

On testing above the best accuracy results obtained in the 2nd test with accuracy of 36.99% with learning rate parameter of 0.05 and maximum looping 2000. For results that have the lowest degree of accuracy in the 3rd test with 30.60% accuracy on parameter learning rate and a maximum of 0.010 looping 2000. The results obtained from test data that hasn't been trained.

3. CLOSING

3.1 Conclusions

Based on the results of the analysis, design, and testing of software and hardware that has been created as a handwriting recognition system with the method of Learning Vector Quantization and Directional Element Feature then it can be inferred that the accuracy is best for images that had previously been trained of 73.80% and for the introduction of that have not been trained on the image of 36.99%. This accuracy is obtained and is influenced by his training parameters, data training and test data are also used in the process of the children's.

3.1 Suggestions

Handwriting recognition applications still have many shortcomings, hence the need for development to be able to produce better accuracy, here are some suggestions to consider:

1. the Required image segmentation method of handwritten text that is attached to each other or stick.
2. It takes a feature extraction method is better for images such as Modify Directional Feature (MDF), Wavelet Transform.

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