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Alphabet Writing Game Application using Template Matching Cross-correlation

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Abstract

The game of writing letters is an attractive learning media. Each person's handwriting is different. So that it requires a data classification method to match the test data with the template that is the alphabet letter. In this journal using a template matching cross-correlation for data classification. Before data classification, preprocessing is done in the form of resize and threshold to produce binary images. Thinning process is also carried out to thin the letters. The thinning algorithm used is stentiford. From the accuracy testing obtained an average value of 70.38%. With the number of letters that continue to experience errors namely the characters H, K, M, and Y.

Keywords: *Template Matching, Cross-Correlation, Handwriting*

1. Introduction

Learning letters that exist in formal schools, usually using the demonstration method. While the learning objectives so that students can apply them to the surrounding environment. Then we need a new method that is practice by doing. The game application acts as a virtual assistant that helps students in assessing the practice of writing alphabet letters. The game application in this journal identifies alphabet letters consisting of 26 letters. Pre-processing is done by changing the size of the image, changing the color of the image to binary. Before data classification, thinning is performed on the image.

Algorithms that can be used in the thinning process are zhang-suen and stentiford. The accuracy of the stentiford algorithm is higher than that of zhang-Suen, although the stentiford algorithm has a longer processing time compared to zhang-Suen [1]. The length of the process is due to the algorithm of stentiford which is done by matching several template images with a size of 3x3 pixels [2]. Whereas in the zhang-Suen algorithm, thinning is done on a pixel based on the surrounding pixels and if the surrounding area is not part of the skeleton of the image [2].

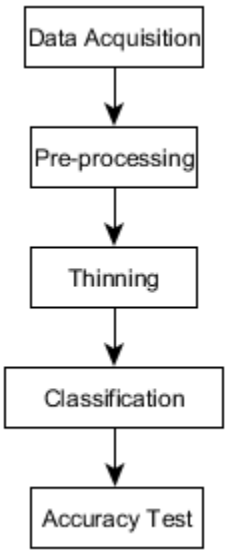
Template matching is part of the data classification method. The step of this algorithm is to match the image with one or more templa

te images with the condition that it has a fixed or symmetrical position [3]. In the OCR (Optical Character Recognition) test which converts printed documents into digital documents using a cross-correlating matching template, an accuracy of 92.90% is obtained [4]. This method is also used in studies that classify hangul letters (Korean), the accuracy obtained is lower at 83.33%. research conducted in these journals did not use handwriting as test data [5]. While this research uses handwriting as an input image. So that more test data and each image studied is different or varied.

Based on previous journals, in this journal thinning uses the stentiford algorithm. While the data classification uses the template matching cross correlation method. The cross-correlation method used in this journal has a difference that is not normalized. Because when the image is inputted (test data) it is limited to binary images that have values 1 and 0.

2. Research Method

The steps of this game application are data acquisition to get training data. Then students write the letters on the canvas which are then carried out pre-processing, thinning, and data classification to determine whether or not the writing is made (determine the level of accuracy).



Picture 1. Research Stage

2.1. Data Acquisition

Writing good letters is writing that is like digital letters. Then the data needed is secondary data from digital letters. Digital alphabet letters with Arial font types are used as training data. The Arial font type has the advantage of having less noise when resizing. Then the amount of training data obtained is equal to the number of letters of the alphabet (26 letters).

Picture 2. Alphabet Template on Character A

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2.2. Pre-processing

a. Resize

The data obtained in handwriting is 192 x 192 pixels. pixel length is used to make it more comfortable in hand writing. The size of the template used is 64x64 pixels. The template matching method matches each pixel. Therefore, it is necessary to change the size of the input data to the size of the existing template. So that the matching position of each pixel matches the data entered with the template.

b. Thresholds

Based on the theory of tristimulus vision, it was found that the human eye sees color through 3 visual pigments (red, green, and blue) in the retinal cone [6]. The theory of vision is the basis for displaying image output from a monitor called RGB. In this journal, the color input obtained from handwriting is an RGB color model. The data entered in the form of handwriting is black or in RGB worth (0.0,0) and white background or in RGB is worth (255,255,255). Then from the data obtained values from each pixel are 1 for black (0.0,0) and 0 for white (255,255,255).

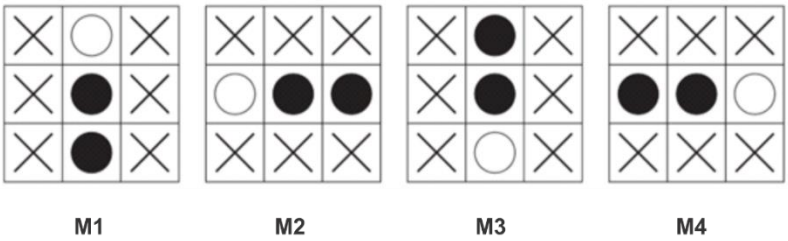
2.3. Thinning

The thinning stentiford algorithm was described in 1983. This thinning algorithm uses a template with a size of 3x3 pixels. The thinning process is carried out on binary images that have black or white color. The general rule of this algorithm is by removing the midpoint (changing the color of the pixel to white) from the 3x3 pixel that is compatible with the existing templates. The steps of the sentiford algorithm are as follows:

1. Find the location of the pixel (i, j), when the pixel in the image or image I matches the M1 template.
2. If the pixel is not included in the end point, and has a connectivity value equal to 1, then the pixel is marked for later eliminated. Endpoints indicate that the midpoint of the 3x3 pixel has black and the surrounding color must be black. The connectivity value is obtained from the 3x3 pixel with the calculation in the form of source code as follows:

```
k1 = gambar[1][2] - (gambar[1][2] * gambar[2][2] * gambar[2][1]);
k2 = gambar[2][1] - (gambar[2][1] * gambar[2][0] * gambar[1][0]);
k3 = gambar[1][0] - (gambar[1][0] * gambar[0][0] * gambar[0][1]);
k4 = gambar[0][1] - (gambar[0][1] * gambar[0][2] * gambar[1][2]);
Konektivitas = k1 + k2 + k3 + k4;
```

3. Repeat steps 1 and 2 for all pixel locations that correspond to the M1 template.
4. If there are pixels that have been removed in step 5, then repeat the previous process from step number 1. If no pixels have been removed at that step, the process can be terminated [2].



Picture 3. Templates on Thinning Stentiford

2.4. Classification

Template cross-correlation matching is a method used to classify image data between test data and templates. Data classification is done by matching the two images. The matching method is by crossing each pixel between the test data image and the template, cross occurs at the same position between the two images [7]. All cross results from the pixels are added to be used to determine the class of the test data. The calculation to get the correlation of 2 pieces of image matrix is aimed at the following formula:

$$R(x,y) = \sum_{x',y'} (T(x',y').I(x+x',y+y'))$$

Explanation:

R : Correlation value between 2 pieces of the matrix, that is image with a template.

T : Matrix of the template.

I : Matrix of the image or test data.

x : Row of image matrix or test data.

x’ : Row of template matrix.

y : Column of image matrix or test data.

y’ : Column of template matrix.

Image used is a binary image of value 1 and 0 or black and white. From the formula above, if the template is 1 with the test data is 1, then the correlation value also produces a correlation value of 1. Meanwhile, if the template has a value of 0 with test data valued at 0 or 1 then it produces a correlation value of 0. So that the correlation between the template with the image, has the highest value, namely the number of image templates that are worth 1 (black). So, in this journal the test data belongs to the class of data if the correlation value has an amount of 85% of the magnitude of all black pixel templates.

2.5. Accuracy Test

The level of accuracy is determined by using the application on 5 tests for each alphabet (130 test data). Testing by inputting test data in the form of handwriting and checking the compatibility of the results of data classification (using a template matching cross-correlation) with the actual output. Divide the number of matching alphabets by 26 (the total number of the alphabet) for every 1 test used to get the level of accuracy.

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3. Result and Discussion

In the preprocessing stage, resizing has been successfully carried out by obtaining a pixel size from the matrix that is equal to 64x64 pixels which originally sized 192x192 pixels. In addition, the threshold process is successful by obtaining all color data from image 255 or 0 (binary image). So that the preprocessing process has been successfully carried out with an image that matches the output that will be used for classification using a template matching cross-correlation.

Picture 4. Threshold Results

Thinning uses stentiford algorithm. In the thinning process, the image is successfully thinned by obtaining 1 vector line. Can also be said, that the results of this thinning image is the skeleton of handwritten input.

Picture 5. Thinning Result

Based on testing the accuracy level obtained the lowest value of the match is 65.38%and the highest value is 84.61%. The average value of the accuracy of the alphabet match was 70.38%. The magnitude of accuracy is influenced by handwriting as test data and digital letter images as training data or templates. Accuracy values can change, because the writing of people every time has a small chance to always be the same.

Table 1. Accuracy of Template Matching Cross-correlation

Testing Number	Matching Alphabet Values		Percentage of Accuracy
	Same	Different	
1	20	6	76.92%
2	22	4	84.61%
3	18	8	69.23%
4	17	9	65.38%
5	17	9	65.38%
6	17	9	65.38%
7	17	9	65.38%
8	18	8	69.23%
9	18	8	73.08%
10	17	9	69.23%

In testing the level of accuracy also obtained information related to characters that often do not match the template used. Characters that often do not match based on the alphabet H, K, M, and Y. based on their characteristics, if divided into 2 area, then all the letters have similarities in symmetry in the horizontal and vertical regions. Another similaritiy is the horizontal and vertical gaps.

Table 2. Detailed Accuracy of Template Matching Cross-correlation

Testing Number	Different Alphabet Details
1	H, J, K, M, P, Y
2	H, K, M, Y
3	A, H, K, L, M, N, P, Y
4	A, F, H, K, M, N, P, R, Y
5	A, F, H, K, M, N, P, R, Y
6	A, H, J, K, M, N, P, R, Y
7	A, F, H, K, M, N, P, R, Y
8	A, H, K, M, N, P, R, Y
9	H, K, M, N, P, R, Y
10	A, H, K, M, N, P, R, Y

4. Conclusion

The average accuracy in this journal was lower than the previous journal, which was 70.38%. Although the data classification method is the same, namely template matching cross-correlation. Low accuracy obtained because there are the same errors occur in the characters H, K, M, and Y. From these errors it is known that each character has its own characteristics. Characteristics of such characters have vertical and horizontal symmetrical sides. Another feature is the horizontal and vertical gaps.

From a low level of accuracy, it is recommended to extract features before data classification. feature extraction that can be used like fourier spectrum features. This feature is able to identify horizontal and vertical gaps. Other things, it requires a machine learning method that uses more training data. Due to the possibility of people's writing is different than digital writing. The data classification methods that can be used are K-Nearest Neighbor, Support Vector Machine, and Neural Network.

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