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THE PERFORMANCE ANALYSIS OF TEMPLATE MATCHING SYSTEM IN LETTER IMAGE RECOGNITION USING ZONING FEATURE EXTRACTION AND INTEGRAL PROJECTION FEATURE EXTRACTION

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Abstrack

Pattern recognition system has been widely applied in pattern recognition, especially the letters image. In letter pattern recognition, feature extraction process is also required to obtain characteristics and specific feature of each image to be recognizable. There are various kinds of extraction of characteristics that can be used in the process of pattern recognition. In this research used two feature extraction of zoning and integral projection.

In this study there are several stages of the process undertaken the design and implementation of systems for image object recognition alphabet capital letters A, I, U, E, O, B, C, D, F, G with a font style Arial created with Microsoft Word and printed on paper. The first stage is capturing which is the process of taking pictures the image of the letter. The second stage is the conversion of RGB image of the letter to the image intensity and image intensity will be segmented using bi-level luminance thresholding method. The next process is the labeling and filtering, followed by the process of feature extraction using zoning and integral projection methods and the results of this extraction will be recognized by the template system matching. Tests conducted on 450 images obtained letters from the image of alphabet capital letters A, I, U, E, O, B, C, D, F, G with font size 30, 40, 45, 50, 60, 65, 70, 80 , 85, 90, 100, 105, 110, 115, 120 and the distance between camera and letter image are 15 cm, 20 cm and 25 cm. In this study would also analyze the performance of template matching system for each feature extraction of test data that has previously been used as a database system and the test data outside the database system.

Test results show that the template matching will work optimally if the data are used as test data, have previously been used as a database system and the system will work less than optimal if the data are used as test data outside the database system. The percentage of the template matching recognition for testing with test data that has become a database system for each feature extraction is 100% and the average percentage of template matching recognition for testing with test data outside the database system is 67.3% for couples zoning and template matching and 72.2% for couples integral projections and template matching.

Key words: image, feature extraction, integral projection, template matching, zoning

1. Preface

Advances in information and technology are evolving so rapidly this century. And it all happened against the backdrop of the human desire to go ahead and make human activities more easily done. In doing everyday activities both personal activities and activities related to the job, now it has been much aided by the results of technological advances and the information itself. Thus, in some human activities need only punch a few buttons, or just out loud, then what he wants done by the tools that became a substitute for hand, foot or mind.

All of these developments can not be separated from the tenacity of the scientists or scholars who continue to do research on science and technology for the sake of efficiency of human activity.

Greatness wills of the computer at this time cannot be doubted. In the field of computer vision has also been many significant achievements obtained by the researchers. Computer vision is a term in a process that aims

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to make useful decisions about real physical objects and of a scene based on images obtained from sensors such as cameras or the other.

One application of technology development related to computer vision is how an engine computer can recognize objects in images. Although object recognition is very easy to do with human vision, but the automation of processing on the computer requires a variety of image processing techniques to recognize an object. The human eye is a very complex visual system. The recording process and the introduction of objects (object recognition) on the human eye are in one system is intact, so that the human eye can immediately recognize and define the object and background, as soon as eye shadow to capture and record an image. So, to make a visual system of the machine based on the results of optical devices requiring prior processing.

The objects recognition like these eyes inspired researchers to develop computer applications for the automation of image processing to recognize objects. In realization of this application takes at least an engine computer and camera as a sensor. The camera used to capture images of objects in front of him. Computers are used as a machine that can process data images from the camera and eventually recognize the image of the object in front of him. Important stages in the process of image recognition object, namely the introduction of object images off line by utilizing the characteristics or features of the image object. Characteristics of image-objects in the input is used as a comparison with the characteristics of the object image stored on a database so that the process can recognize any pictures of objects that are input by the user. The process of comparison features of object images that are input with the features images of objects that exist in the database named by the template matching process.

Based on the thinking and research above, the authors are interested to implementing it with compare between the two feature extraction that is focused on the letters of the alphabet capital letter with image acquisition using a camera and using a template matching as a pattern recognition technique. This process is structured in the final task of the study, entitled "The Performance Analysis of Template Matching System in Letter Image Recognition Using Zoning Feature Extraction and Integral Projection Feature Extraction".

2. Literature Review

2.1. Image Formation

Image formation process can be represented by Figure 2.1

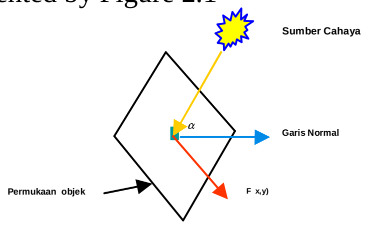


Figure 2.1 Image *formation process*

Surface of the object get the rays of light sources. Number of beam (illumination) of light received by the object at coordinates (x, y) is i (x, y). Object reflects light it receives with the degree of reflection r (x, y). The product of i (x, y) and r (x, y) states of light intensity at coordinates (x, y) is captured by the visual sensor in the optical system, so it can be expressed by the equation below.

$$f(x,y) = i(x,y) \bullet r(x,y) \quad (1)$$

Where:

a. f (x,y) = light intensity at the coordinate point (x, y) on the image.
b. i (x,y) = the amount of light emitted by light source (illumination), a value between 0 and infinity.
c. r (x,y) = degree of ability to reflect light in the object (reflection), a value between 0 and 1.

The light source affects the value of i (x, y), while r (x, y) is determined by the characteristics of the object in the picture. Values of r (x, y) = 0 indicates total absorption, while r (x, y) = 1 states the total reflection. If the surface has zero degrees of reflectivity, the light intensity function f (x, y) is also zero, which means that images can not be captured by the visual sensor. Conversely, if the surface has a degree of reflectivity, it functions the same as the illumination intensity of light received by the surface, this means that images captured by the visual sensor close to the original, depending on the quality of the visual sensor.

2.2. Image Digitizing

An image must be represented numerically by discrete values in order to be processed by a digital computer. Image representation of the continuous function into a discrete value called digitizing. The resulting image is called digital image (digital image). In general, the digital image of rectangular, and dimensions of its size expressed as width x height (or width x length). Each element in a digital image (matrix elements) is called the image element, picture element or pixel (pixels). Digital image of size N x M matrix commonly expressed with a size N rows and M columns. Thus, the image size N x M having NM pixels.

Row indeks (*i*) and coloumn indeks (*j*) represent a coordinate point on the image, while f (i, j) is the intensity (degree of gray) at the point (i, j). For example, suppose an image measuring 256 x 256 pixels and is represented numerically by a matrix consisting of 256 lines (in-index from 0 to 255) and 256 columns (at-index from 0 to 255).

The process of digitizing the image consists of two stages:

a). Spatial Digitization of (x, y), often referred as sampling.

Sampling stating the amount of boxes arranged in rows and columns. In other words, sampling defines the size of the image pixels in the image.

For ease of implementation, the number of sampling is usually assumed to be powers of two,

$$N = 2^n \text{........................ (2)}$$

Where,

N= number of sampling on a row or column

n= positive integer

The images division into a certain size determines the spatial resolution obtained. The higher the resolution, which means the smaller the pixel size (or more the number of pixels), the finer the image obtained because of missing information due to grouping of degrees of gray in the sampling increasingly small.

b). Digitizing the intensity of f (x, y), often referred as quantization.

After the sampling process, the next process is quantization. Quantization defines the levels of brightness values expressed in the gray level (gray scale) according to the number of binary bits are used, in other words the quantization on the image stating the number of colors in the image. Quantization process of dividing the gray scale (0, L) become an amount of G-level expressed with a price of integers (integer), G is usually taken powers of 2,

$$G = 2^m \text{...(3)}$$

Dimana,

G = derajat keabuan

m = bilangan bulat positif

2.3. Image Segmentation

2.3.1. Definition of Segmentation

Segmentation is the process of partitioning the image into regions (region). If we want to partition the image based on color, then we can do it on each layer of color (either on the HSI or RGB). Image segmentation is one of the basic level image processing. Because of the process of image analyses had been done and then change the overall look of the image.

Some of the benefits of segmentation are to remove unnecessary information and improve the information needed to process the image processing at the next level. In addition, by the separation of image objects into fragments which are distinguished on the basis of this homogeneity, objects form an actual (real) can be recognizable.

2.3.2. Bilevel Luminance Thresholding

Bilevel Luminance Threholding is a segmentation method used in this study. Segmentation method is used only to separate the two regions in the image, the dark areas and bright areas only. This method is very useful to segment the binary image.

Most of image processing performed by processed the existing colors in the image. Color is an important component in the process of object recognition, because the color can be used to distinguish between objects with the background.

Segmentation process starts from the determination of the color that wants to be segmented. Intensity color space / luminance used in this study as the threshold parameter. Examples of the segmentation process can be seen from the stage below:

a. Scanning the coordinates of pixel (i, j) in image capture results.

b. Get the value of R, G and B in the coordinates of each pixel. Converting RGB color into intensity values.

c. If found the value of the intensity above the threshold value (considered as an object) is changed to r = 255, g = 255, b = 255 (white), whereas the intensity values below the threshold value (considered as background) is changed to r = 0, g = 0, b = 0 (black).

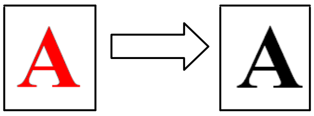


Figure 2.2. Examples of bilevel luminance thresholding segmentation results

Image object of segmentation results in this research are black while the background is white. It aims to facilitate the further processing, ie filtering and integral projection and zoning.

2.4. Filtering

The steps of filtering the image component in this research can be stated as follows:

a) Scanning the pixels coordinates of segmentation results image.
b) Determine the saturation value of each pixel coordinates by using the value of r, g and b in each of the coordinates of the pixel. The Equation to find the saturation value of each pixel can be seen from the following equation.

$$S = 1 - \frac{3}{R+G+B} \min(R,G,B) \quad (5)$$

c) If there are found the value of the saturation value is 0 on the pixel coordinates then the pixel is labeled 0.
d) If found the value of the saturation value greater than 0 then the coordinates of the pixel given a particular label value. Coordinates of pixels that have been labeled will examine the eight neighboring pixels around it. If the coordinates of neighboring pixels having saturation values are also greater than 0 then rated the same label. After the initial labeling, if it is found the coordinates of pixels that have saturation values greater than 0 rated the label, but if the label is the label of the old or new is determined by examining eight neighboring pixels if not among the eight neighboring pixels have a label, then the coordinates of the pixel rated a new label.

If the image segmentation results are labeled entirely, then performed thresholding on the value of a particular label, which will eliminate the thresholding value labels which amounts smaller than the threshold value. Value labels which amount smaller than this threshold value are considered as noise.

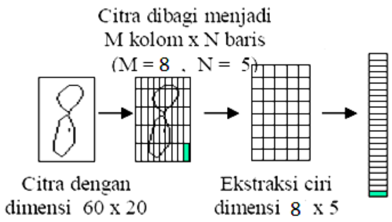
2.5. Feature Extraction [11]

A feature of the image is a simple process of determining the characteristics or properties of an image. Some features are a natural, in the sense that the trait is determined by the visual sight of a picture. In the other hand, the artificial features are a result of specific manipulation of an image. Luminance pixel area and the composition of the gray scale are included to natural features . Image histogram amplitude and frequency spectrum based on the place (spatial frecuency spectra) are examples of artificial features.

The characteristic of the images are very important in separating the general nature of an area within an image (image segmentation) and subsequent identification or labeling area (image classification).

2.5.1. *Zoning* Method

One method of feature extraction is a method of windowing. In this method, the numbers that contained in the image file is converted to the order code number (between 0 and 1). Each box done scanning pixels, and sought its average value, by counting the total number of pixels that active divided by the number of pixels per box. Figure 2.3 shows the process of feature extraction [6].



Gambar 2.3 Visualisasi ekstraksi ciri

2.6.1 Integral Projection Method.

Integral projection is the process of changing the form of an image into a graph model. Integral projection is a method used to search the area or location of the object [4]. This method can be used to detect the boundaries of different image regions, so that we can get the image location and its features.

Integral projections are divided into two, namely the vertical integral projection and horizontal integral projections. Therefore, this method can also be referred to the integral lines (horizantal) and column (vertical) of pixels, because this integral summing the pixels per line and pixel per column. Integral equations for the horizontal projection is shown by equation (6), while the integral equation for the vertical projection shown by equation (7) [1]:

$$IPF_v(x) = \int_{y_1}^{y_2} I(x,y)dy \quad \ldots\ldots\ldots\ldots\ldots (6)$$

$$IPF_h(y) = \int_{x_1}^{x_2} I(x,y)dx \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Description :

I (x,y) = intensity on the degree of gray pixels (x, y) from the image of the object.

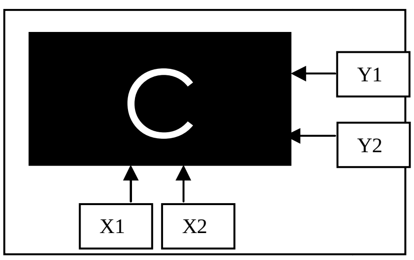


Figure 2.4. Calculation regional of Integral Projection

The image above shows the distribution of the integral projection counting area of a frame that has a letter.

Areas of x1 to x2 are an integral horizontal projection of the letter C. Then do the sum of white pixels (object image) of each row along the y1 to y2 so that it will obtain the graph of the sum of pixels. Area from y1 to y2 is an integral vertical projection of the object image. Then do the sum of white pixels of each column along the x1 to x2 in order to get a graph of the vertical integral projection [6].

From this integral projection method we will get the sum of rows and columns that will be us if or further processing. We add up the pixels in the direction x and y axis width of our number of pixels along the x or y as high, so we will know the height and width of the image, from here we've got the location of the object we seek.

By using integral projection chart, will facilitate the introduction of a variety of drawing letters, because each letter has a graphic image projection integral different, both vertical and horizontal integral projections. Examples of integral projection for drawing graphs of certain letters can be seen in Figure 2.5.

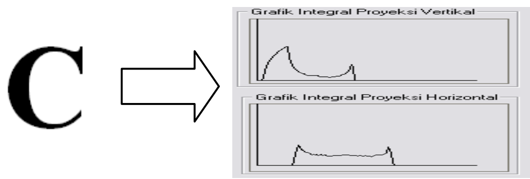


Figure 2.5. Integral projection graph on C letter image.

2.7 Template Matching

Template matching is a method used in order to determine the similarity of two images. Two pictures that meaned are the template image and the image query. Both of the images are feature extracted using the integral projection. From this integral projection graphs would searched the distance between the template and query images. Query images that have a minimal distance with the template image are an image that has the greatest similarity with the template image. The distance in question is the difference between zoning or integral projection graph of template image and image query. The equation used to calculate the distances are as follows:

$$d = \sum \left\| \alpha_i^1 - \alpha_i^2 \right\| \text{..........................} \quad (8)$$

Where,

d = difference between new image matrix and image data matrix in database

α_i^1 = new image data matrix (*template*).

α_i^2 = image data matrix in a database system (query).

Value of the difference (d) of the smallest signal that compared the two images has the greatest similarity.

3. Research Methodology

Research Step

1. Stage begins with the capture or shooting of a letter by a web camera connected to a computer. Captured by the camera frames are then stored in the camera memory buffer.
2. The results of the capture then processed to the next image processing stage which is segmentation. In this stage the separation of certain areas or sections is done in order to get the entered form letter.
3. Then the filtering process is performed on each object in pixel coordinates.
4. From the results of filtering were performed characteristics / features detection of the shape of the letter image. Here used zoning or the integral projection method.
5. The results of the characteristics / features detection of the form letter by letter, then matched with the results of the characteristics detection of letters stored in the database.
6. Capture process, segmentation, filtering and detection characteristics of the letters so that the characteristics of the data obtained the letters are then stored in a database has been done previously.
7. If in the process of matching the similarity between the data obtained from the input with data stored in the database, then this information will be displayed in text form.

4. System Design

4.1. *Capturing*

Image of the letters are first converted into digital data by being captured or photographed using a camera. In this research used the camera phone to capture the image of the letter. The image will be captured on a three distance which are 15 cm, 20 cm and 25 cm and a picture letter that will be placed in front of the cameras at the center position of the video display. These capture results is a video with single frame. The image that has been taken will usually have a loss of quality, so it is necessary to process the image processing to improve image quality.

4.2. Convert to Intensity Image

Image results in the form of image capture camera with RGB color space, so RGB color conversion is carried out into the intensity values, this is done because at 7.04 Matlab software can only process the intensity image to binary image and can not process RGB images into binary images.

4.3. Segmentation

Segmentation is part of the image processing to distinguish or separate the number of objects in an image from its background to facilitate image processing at a later stage. In this research used bilevel luminance thresholding segmentation method. This method separates the dark and bright areas on the image using the intensity or luminance color space as its threshold parameter. At this stage, the intensity values at each pixel scanned based on the previous process of conversion from RGB image to the image intensity. In coordinate pixels that have intensity value above the threshold value, will given the value 1 and which is under the threshold value will be assigned a value of 0 where the value 1 itself is white and the value 0 is black.

4.4. Labeling and Filtering

Letters image that have been segmented then processed to further step named labeling and filtering. Labeling itself is part of the image processing to give a different label for each object of the segmentation process. This labeling process will be used to determine which objects will be retained and which objects will be removed and used also to calculate the area of the object. Then the minimum area of the object specified. When breadth is less than the minimum, it will be considered as noise and will be removed in the process of filtering. And if the breadth equal to or greater than the minimum area, it will be regarded as an object.

The process of removing objects that are considered as part of the noise named filtering. It aims to improve image quality by removing noise that is there. Removing noise is necessary for giving effect at the time of training and testing.

4.5. Feature Extraction

Feature extraction is the process to take certain features of the observed characters. In this research, the use of feature extraction zoning is by dividing the image into several areas of observation and then calculates the number of active pixels in each area of observation.

In this study also used the integral projections feature extraction. Extraction process performed using the method of integral projection. An integral projection used in this study is the horizontal integral projection. Horizontal integral projection is the summation of pixels of each column from left to right in a row.

By using integral projection graph, then each letter or number of objects will have a unique value of the integral projections that can assist in the process of object recognition.

4.6. Template Matching

Template matching is a method used to see the similarity of two pieces of the object. With this method will be compared zoning feature extraction outcome data of template image objects and zoning feature extraction outcome data from images query object. Template object image data is an image data that has been stored in system, while the query object image data are data from the input object image captured by the camera.

In this matching process, the zoning of the image data of the query (input) minus the value of the data of zoning that has been stored in the system (the template). Value of the existing zoning of the data stored in the system in notepad form that sorted by certain criteria. Each file is to be taken sequentially scanning the data value of its zoning. If the difference between the new zoning data with zoning data previously stored in the template having the smallest difference value, then the data will be considered as the image data are most similar objects.

4.7. Matrix Testing

The results of system performance will be evaluated through a test. In this test the image data entered into the system to be identified and then displayed on the GUI (Grafic User Interface).

Tests using 300 characters from the training data using the Arial font type and use 150 characters test data of this type of Arial.

4.8. Test Scenario

In the research of this letter image recognition system there are several scenarios:

a. Recognizing and reading of the input of letters that have previously been used as a database system for pairing zoning - template matching.

b. Recognizing and reading of the input of letters that have previously been used as a database system for projection integral partner - template matching.

c. Recognizing and reading of the input of letters outside the database system for pairing zoning - template matching.

d. Recognizing and reading of the input of letters outside the database system for projection integral partner - template matching.

5. Result and Analysis

5.1 Test Results

Tests performed on this system to see the influence of the distance between the cameras and the object to the percentage of success of the system. In this testing system will be calculated the percentage of success for each of the letters A, I, U, E, O, B, C, D, F, and G with a variation of the distance between the camera with the image will be captured that is 15 cm respectively, 20 cm and 25 cm. Percentage graphs of success of the system in recognizing the image of the letter can be seen in Figure 5.1.

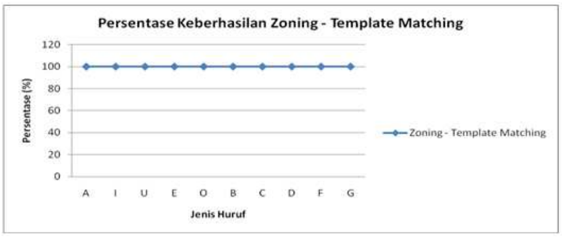


Figure 5.1. Graph of system success for the pair of feature extraction zoning and template matching system.

In figure 5.1 above is the chart success of the system for zoning and template matching pairs. Tests carried out 5 times for this couple. In this test, the system will be tested to identify images that have been treated previously with zoning feature extraction. However, the data used as test data is data that has been stored as a database system. As a result, could be seen that the success of the system in recognizing the letter image is 100% for each letter and 100% for the entire test.

The success of the system at the next test can be seen in Figure 5.2.

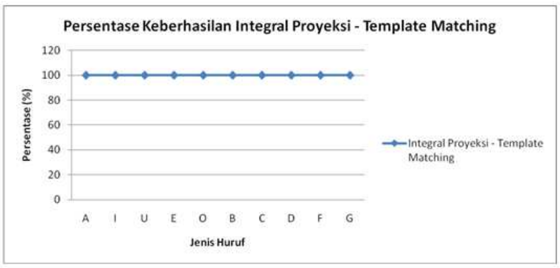


Figure 5.2. Graph of system success for the pair of feature extraction integral projection and template matching system.

In figure 5.2 above is the chart success of the system for integral projection and template matching pairs. Tests carried out 5 times for this couple. In this test, the system will be tested to identify images that have been treated previously with integral projection feature extraction. However, the data used as test data is data that has been stored as a database system. As a result, could be seen that the success of the system in recognizing the letter image is 100% for each letter and 100% for the entire test.

The success of the system at the next test can be seen in Figure 5.3.

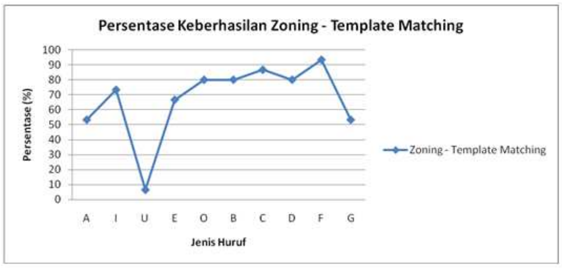


Figure 5.3. Graph of system success for the pair of feature extraction zoning and template matching system.

In figure 5.3 above is the chart success of the system for zoning and template matching pairs. Tests carried out 5 times for this couple. In this test, the system will be tested to identify images that have been treated previously with zoning feature extraction. But unlike the two earlier tests, the data used as test data is new data that does not exist at all in the database system. The new measure used is the font size 45, 65, 85, 105 and 115 with the same image acquisition distance is 15 cm, 20 cm and 25 cm. As a result can be seen that the success of the system in recognizing the image of each letter is 53.3% for the letter A, 73.3% for the letter I, 6.67% for the letter E, 66.67% for the letter U, 80% for the letter O, 80% for the letter B, 86.7% for the letter C, 80% for the letter D, 93.3% for the letter F, 53.3% for the letter G and 67.3% for the entire test.

The success of the system at the next test can be seen in Figure 5.4.

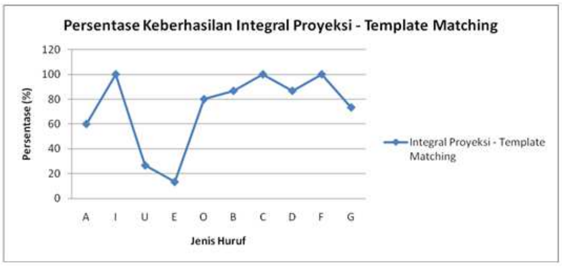


Figure 5.4. Graph of system success for the pair of feature extraction integral projection and template matching system.

In figure 5.4 above is the chart success of the system for integral projection and template matching pairs. Tests carried out 5 times for this couple. In this test, the system will be tested to identify images that have been treated previously with integral projection feature extraction. Like the third tests, the data used as test data is new data that does not exist at all in the database system. The new measure used is the font size 45, 65, 85, 105 and 115 with the same image acquisition distance is 15 cm, 20 cm and 25 cm. As a result can be seen that the success of the system in recognizing the image of each letter is 60% for the letter A, 100% for the letter I, 26.67% for the letter E, 13.33% for the letter U, 80% for the letter O, 86.7% for the letter B, 100% for the letter C, 86.7% for the letter D, 100% for the letter F, 73.3% for the letter G and 72.7% for the entire test.

5.2. Analysis

Based on the above experimental results can be seen that the data that tested on template matching system is very influential in the success of any type of feature extraction system used. In graph 5.1 and 5.2 can be seen that the system will be able to recognize an image very well, in this case 100%, when the data has previously been stored as a database system. For any variations of font type, font size variations, and the distance variations, the system can recognize the image is 100% correct.

This is because the system uses template matching system to recognize the difference in the image. Array of new images that have been obtained from the previous process will be reduced by arrays of images that exist on the database and obtained the difference. The smallest difference value will be considered as the image in question. When we analize, the data that previously has been used as a database system and used again as the test data, it will automatically result the difference between them is zero and certainly the system will be able to recognize that image. Therefore, testing can be managed 100%. This then became one of the advantages of template matching system.

But its shortcomings are less able to recognize the image of the system outside the existing image data in a database system. This can be proved in graph 5.3 and 5.4 above. The system can only recognize a maximum of three quarters of the overall data is tested. For couples zoning - template matching only obtained 67.3% successful percentage of the system and for the integral projection - template matching is only obtained 72.7% percentage of success of the system alone.

6. Conclusions and suggestions

6.1. Conclusions

1. Based on the analysis of experimental results obtained, it can take some conclusions as follows: the success rate of recognition of the test data are previously used as the database system is higher than the success rate of recognition of the test data outside the database system.
2. The treatment of varying distance for feature extraction zoning - matching template pair for test data which is used as the database system obtained a success rate for the letters A, I, U, E, O, B, C, D, F, and G at 100 % and the success of the overall system by 100%.
3. The treatment of varying distance for feature extraction integral projection - matching template pair for test data which is used as the database system obtained a success rate for the letters A, I, U, E, O, B, C, D, F, and G at 100 % and the success of the overall system by 100%.
4. The treatment of varying distance for feature extraction zoning - matching template pair for test data which is used as the database system obtained a success rate for the letters A, I, U, E, O, B, C, D, F, and

G are 53, 3%, 73.3%, 6.67%, 66.67%, 80%, 80%, 86.7%, 80%, 93.3%, 53.3% and the success of the overall system by 67.3%.

5. The treatment of varying distance for feature extraction integral projection - matching template pair for test data which is used as the database system obtained a success rate for the letters A, I, U, E, O, B, C, D, F, and G are 60 %, 100%, 26.67%, 13.37%, 80%, 86.7%, 100%, 86.7%, 100%, 73.3%, and the success of the overall system by 72.7%.
6. The excellence of Integral projections in this system is more rigorous in calculating the number of active pixels of the object so as to provide better results to identify test data outside the data base system but its weakness is needed to perform feature extraction time is longer and larger memory.
7. The excellence of Zoning in this system is to require only a short time in doing extractions, but less rigorous in calculating the number of pixels.

6.2. Suggestion

After analyzing the workings of the system and the system output, for research and further development of this system, the authors suggest several things:

1. The ability of the system can be developed by the method of feature extraction and recognition method to another.
2. For a simple system can be used feature extraction zoning because of its speed but for a more complex system should be used for feature extraction integral projection because of its accuracy.
3. Since template matching is still included in the less intelligent system in recognizing patterns, especially when recognizing the image outside the database system, then for further development of this system, can use the other pattern recognition systems, especially intelligent systems such as Artificial Neural Networks, Fuzzy, or other intelligent systems , so that the recognition system is more flexible and better able to recognize patterns in the image without having to first become the database system.

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